THE UNIVERSITY OF ALBERTA

URBAN NOISE AS A FACTOR IN PLANNING

by

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ABSTRACT

The significance of noise to community planning is the subject of this thesis.

Two scales of measurement, the dBA and PNdB scales, have been developed to approximate human response to noise. These scales, however, do not incorporate other important factors which influence the subjective response to noise. The Composite Noise Rating relates the level of aircraft noise to the time of day and number of overflights. Composite Noise Ratings are calculated on the basis of aircraft operations at the Edmonton Industrial Airport. It is found that extensive residential areas are exposed to noise levels in excess of 100 dBA. Traffic noise is classified as 'noisy' or 'quiet' on the basis of ambient noise measurements conducted at 21 selected sites within the city.

A questionnaire was conducted to determine the feelings and attitudes of residents to the noise created by the two main sources, the motor vehicle and the aircraft. Many respondents experienced disturbance of relaxation and considered the interfering noise unnecessary and a feature of the urban environment which should be eliminated. Only in an area in close proximity to the airport were residents adamant in their demands for a quieter city, in reference to aircraft noise, to the extent that an anti-noise petition was circulated.

Legislation concerned with noise abatement and

control is examined. The Edmonton noise bylaw is found to consist of realistically enforceable limits. The methods of monitoring and control, however, appear to be inadequate. The use of noise nuisance bylaws in conjunction with other legislative controls, such as zoning, is examined.

The incorporation of Composite Noise Ratings into the zoning bylaw is found to represent a realistic and meaningful approach to the planning of an airport city, such as Edmonton. The need for further research into the individual resident's perceptions of and reactions to urban noise and the incorporation of all new findings into planning decisions is suggested.

ACKNOWLEDGEMENTS

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CHAPTER ONE

INTRODUCTION

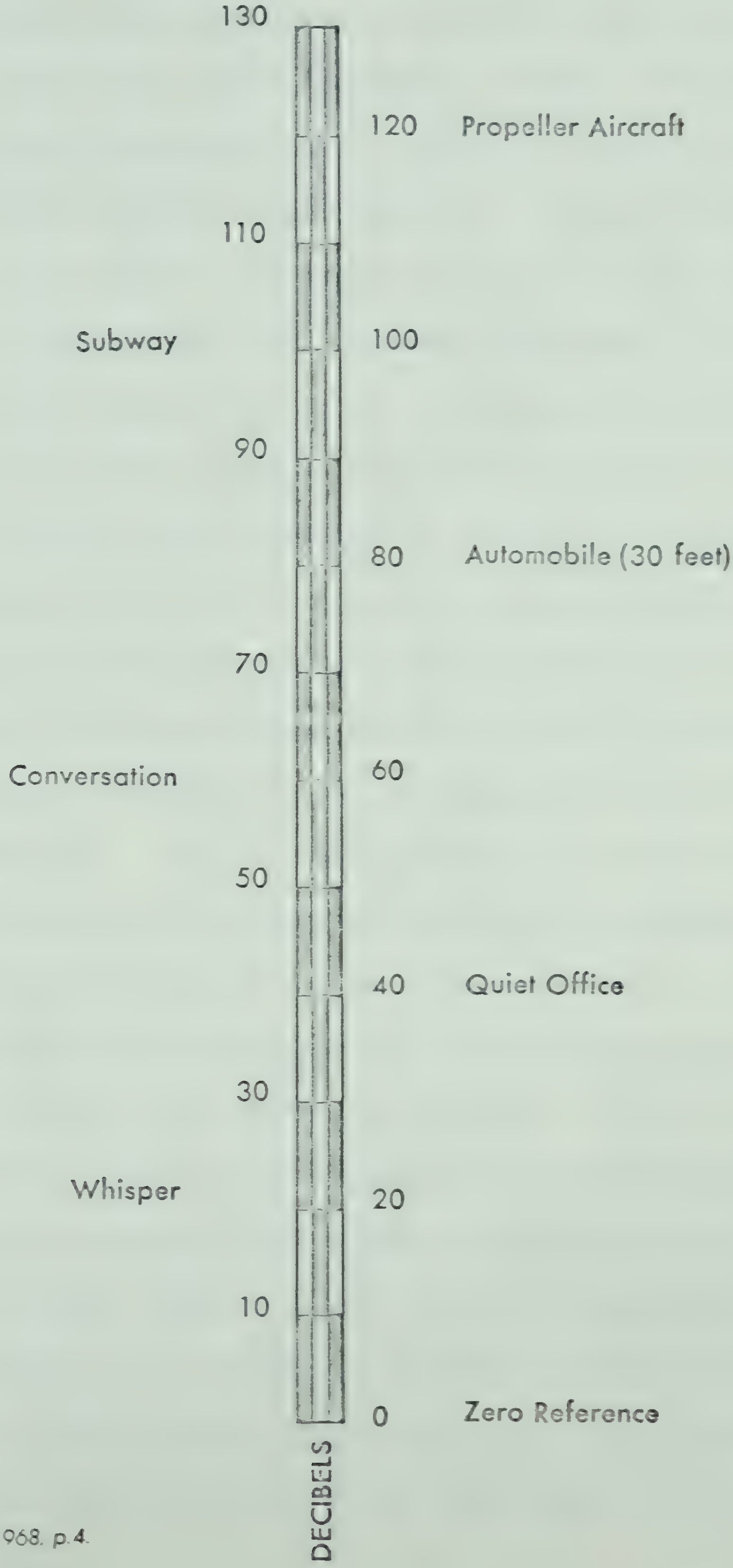
1.1. The Concept of Noise

Noise is a subjective quality of the environment. Derived from the Latin 'nausea', the word, noise, is commonly defined as "unwanted sound" or "sound undesired by the recipient" (Committee on the Problem of Noise, 1963, p. 2). Semotan and Semotanova (1969, p. 482) define noise as "any sort of sonic vibration which may exercise noxious influences upon man or disturb him". Studies conducted by acousticians have shown that noise affects the psychological state of an individual and that intense levels of sound will have serious physical effects including permanent deafness (Eldridge and Miller, 1969). The assessment of an individual's environmental perception is the concern of the social scientist. Deciding that an audible sound is disturbing or annoying is a perceptual process in which the individual formulates his own image of the situation within the context of his own experiences, personal preferences, attitudes and values. Hence, noise by being an unwanted quality of the environment as decided by the listener is worthy of the social scientist's study.

The physical property of noise, sound, must be understood if one is to appreciate its influences on the subjective responses to noise. A sound wave (Appendix I) is an "oscillation of pressure, stress or particle displacement in an elastic medium" (Olishifski, 1968, p. 1). This oscillation or motion of the medium is characterized by a fluctuation in the barometric pressure and the ear translates this difference in pressure into an auditory sensation (Rudmose, 1969). Sound pressure is measured in dynes per square centimetre or microbars and the human ear is sensitive to sound pressure between .0002 and 200,000 microbars. This billion-to-one ratio is measured on the logarithmic or decibel scale on which .0002 microbar is equal to 0 decibel (dB) and 200 microbars are equal to 120 dB which is the human pain threshold (Smith, 1970). A soft whisper, as shown in Figure 1.1, has a sound pressure level of 30 dB or a sound pressure of .0063 microbar. A subway train has a sound pressure level of 90 dB which is equivalent to a sound pressure of 63 microbars and the corresponding values for a rocket launching pad are 180 dB and 200,000 microbars.

The frequency of sound is the number of times a pressure oscillation or change in pressure occurs every second and is measured in the unit Hertz (Hz). Frequencies are divided into three ranges: infrasonic (20 Hz and below), sonic (20 to 20,000 Hz), and ultrasonic (20,000 Hz

Figure 1.1 Decibel Values for Some Typical Sounds



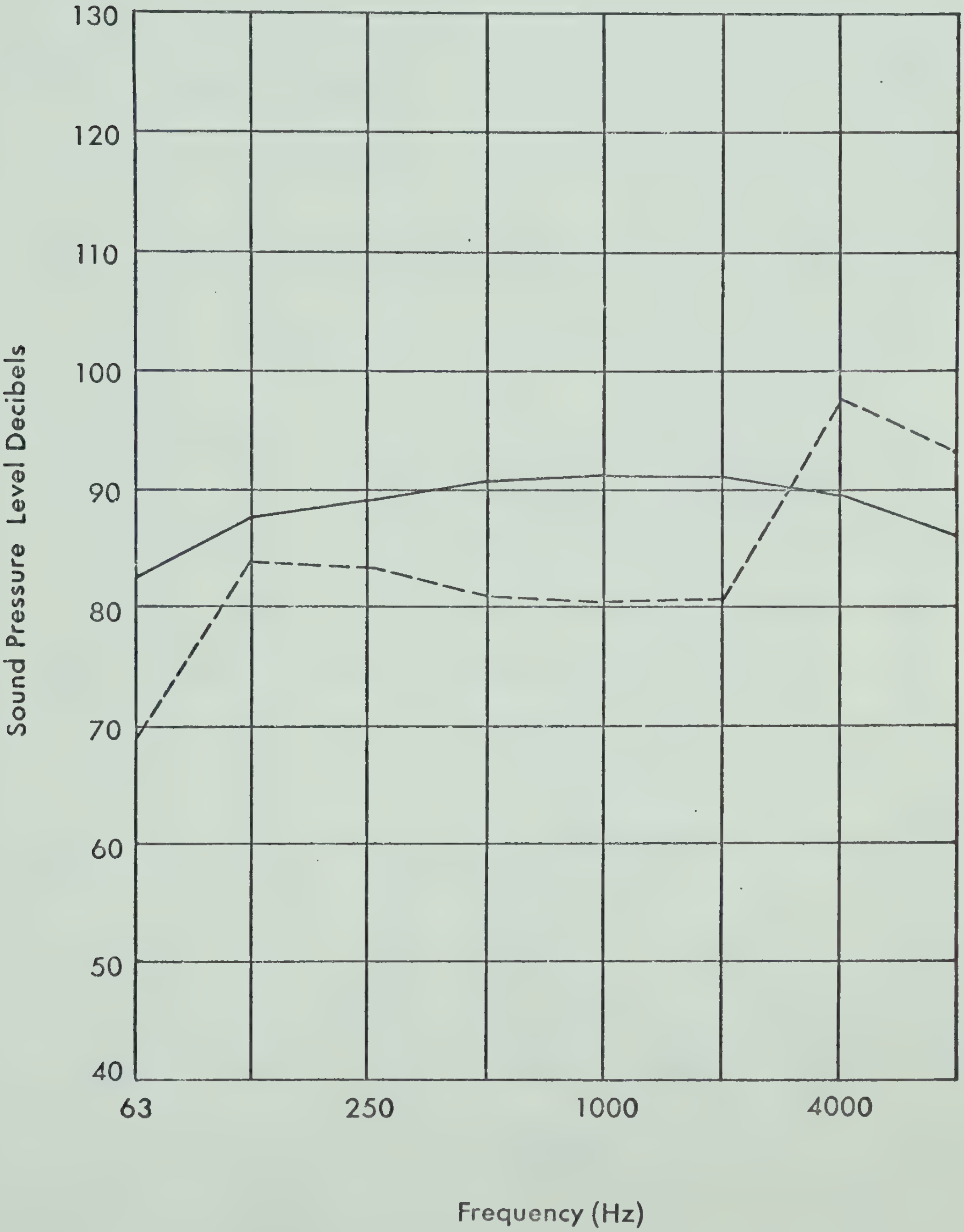
Source:

MD of Canada, 1968. p.4.

and above). Man's speech range is 500 to 2,000 Hz but the average man can hear all the frequencies in the sonic range. Most noise exposure problems are associated with sound frequencies within this range (Rudmose, 1969). The distribution of sound pressure over a range of frequencies may be indicated by an octave band analysis. Figure 1.2 shows the results of an octave band analysis in which two sounds of the same pressure level (98 dB) were analyzed. The difference in the curves is due to a difference in the distribution of the sound pressure over the frequency range.

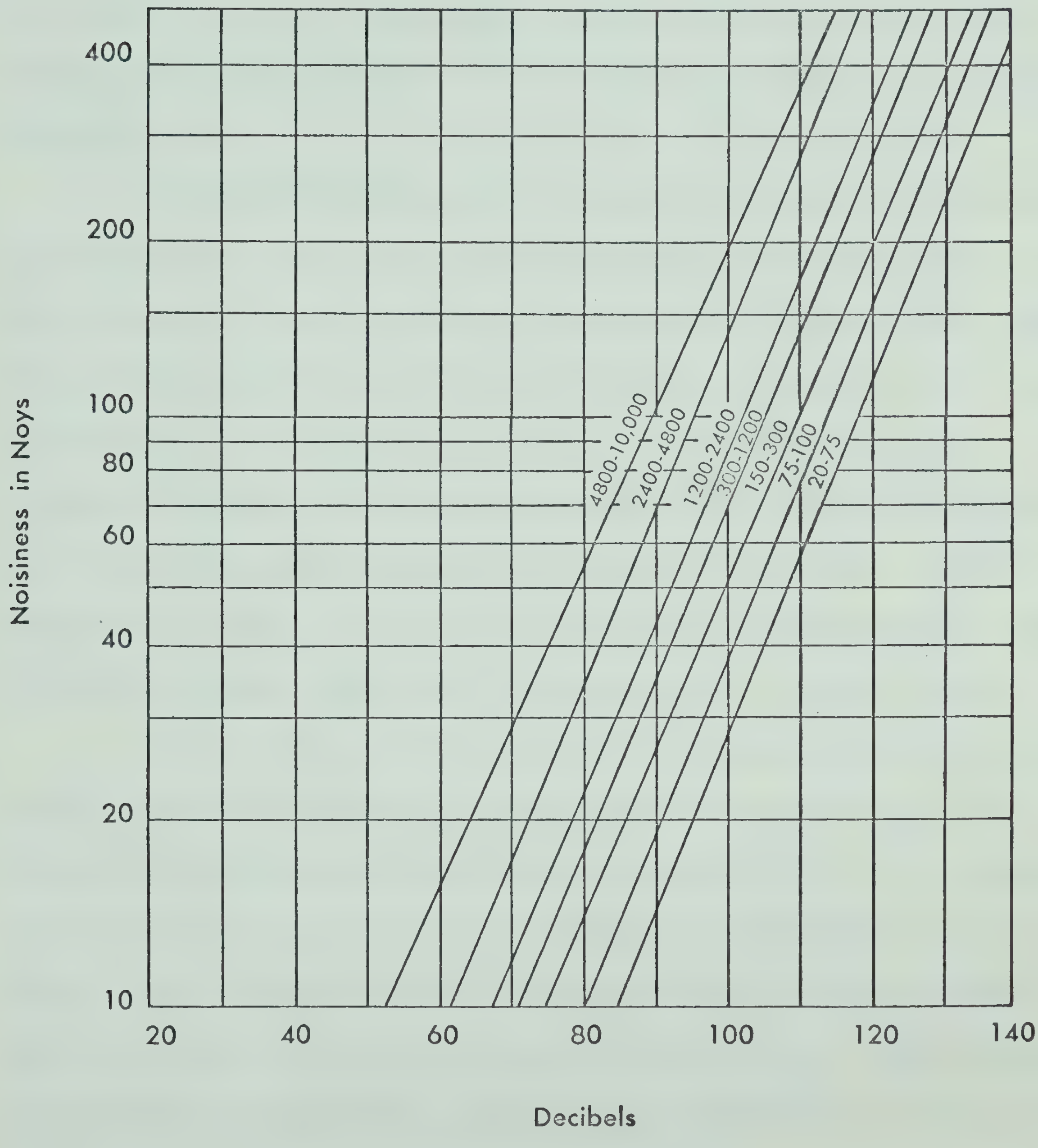
Kryter (1959) has attempted to measure quantitatively the acceptability of a sound, a subjective quality, by considering this relationship between frequency and sound pressure. A linear scale was developed to measure perceived levels of noisiness and the <u>noy</u> was named as the unit of measurement. Noy 1 (one) refers to the perceived noisiness of the band from 910 to 1,090 Hz of random noise at a sound pressure level of 40 dB (Kryter, 1959, p. 1424). Figure 1.3 illustrates the relation between frequency bands, sound pressure levels and noisiness in noys. Sounds of equal pressure but possessing different frequency spectra are perceived differently, the higher frequency sound being perceived as 'louder' (Ward, 1969). This is apparent in Figure 1.3 in which, for example, a noise of the frequency range 4,800 to 10,000 Hz and sound pressure level of 90 dB has a noisiness level of 110 noys as compared to a 14 noy

Figure 1.2 Octave band analysis of two different noises having the same total sound pressure.



Source: *J.B. Olishifski, 1968, p.4.*

Figure 1.3 Relation between sound pressure level in frequency bands and noisiness in noys. The bandwidths are indicated on the curves.



Source: *K.D. Kryter, 1959, p.1425.*

level for a noise of the same sound pressure level but of the much lower frequency range, 20 to 75 Hz. The linear noy scale was then converted into a logarithmic or decibel scale and the resulting value named the perceived noise level (PNdB). Kryter's findings relate specifically to aircraft noise and research is presently being conducted to relate the PNdB concept to other noise sources such as the automobile.

A factor allowing for the ear's ability to discriminate against high and low frequencies is incorporated in the design of sound measuring equipment. Three scales have been developed, the A, B, and C scales, amongst which the A-network, as indicated in Figure 1.4, discriminates strongly against low frequencies and is a good approximation of the human ear's response to noise (Olishifski, 1968). Robinson et al. (1963) have determined an approximate relationship between PNdB and A-weighted (dBA) noise levels.

Other factors influencing the subjective response to noise not accounted for in the above two measuring techniques include duration of the noise, time of day at which the noise occurs, and the frequency of occurrence of the noise. All these factors are significant in determining the annoyance level of a noise. Guild et al. (1964) have developed the Composite Noise Rating (CNR) in an attempt to relate the importance of these factors to the PNdB level. Another approach, the Traffic Noise Index (TNI), as

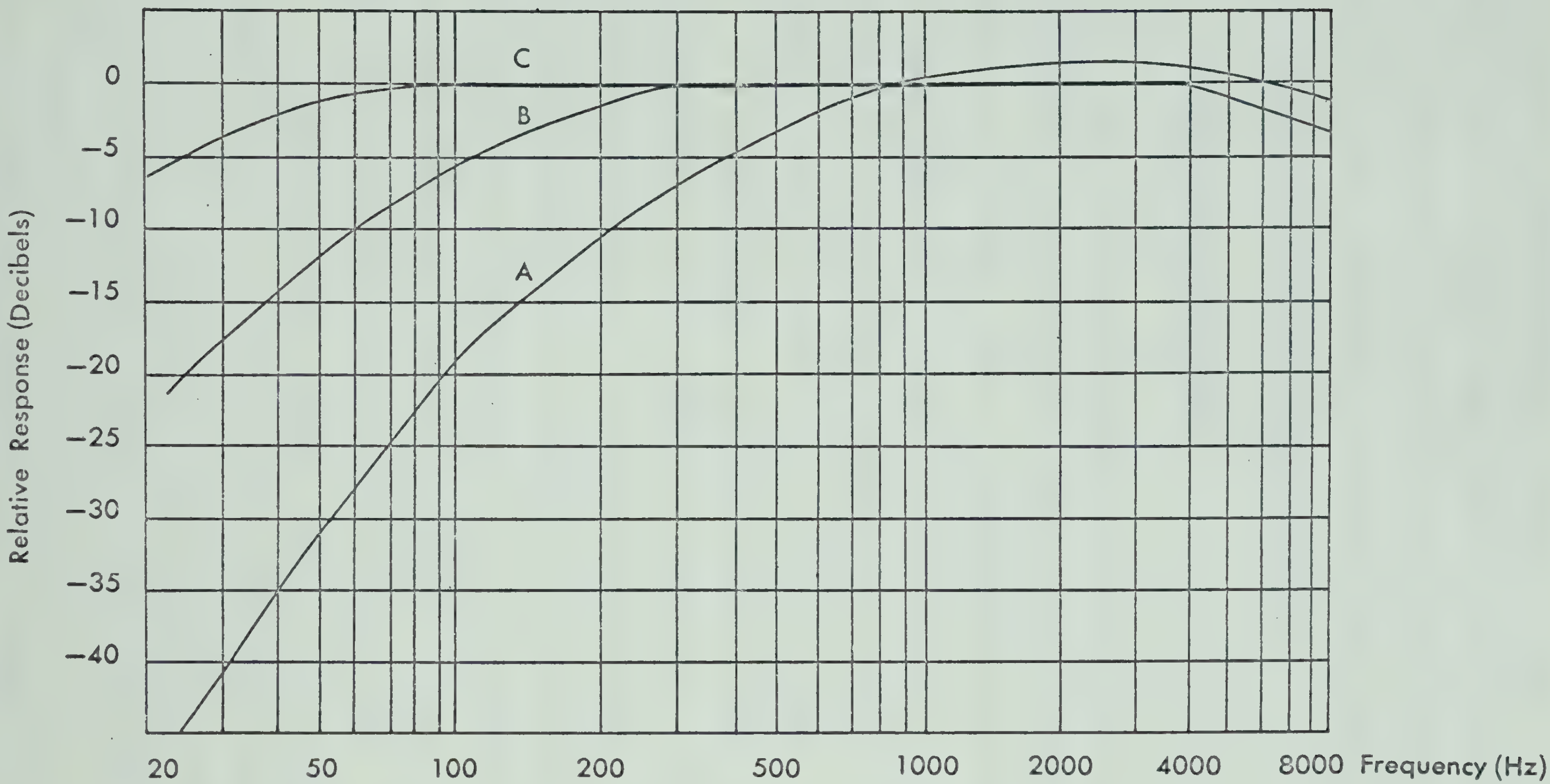


Figure 1.4 The internationally standardized weighting curves for sound level meters. The instrument transforms sound pressure into voltage by a microphone and a weighting network shapes the voltage to account for the desired frequency response. The A—scale weighting corresponds to the response of the human ear.

Source; *J.T. Broch, 1969, p.36; and J.B. Olishifski, 1968, p.5.*

developed by Griffiths and Langdon (1967), is a composite measurement which attempts to predict dissatisfaction with noise conditions by investigating road traffic noise on the dBA scale and measuring the mean sound levels exceeding 90 and 10 per cent of the sampling time.

1.2. Objectives of Study

Two sources of urban noise are investigated in this thesis and the PNdB and dB concepts are selected as the measurement units. Noise from aircraft operating from the Edmonton Industrial Airport is measured on the PNdB scale and noise arising from automobiles, trucks, and public transit buses is measured on the dBA scale.

A discussion of the selection of the study area and a description of the method of measurement in which objective measurements of the physical parameters of noise are made according to internationally standardized procedures are presented in Chapter Two. The findings of these measurements are then employed in Chapter Three to describe the present noise environment of the study area.

An increase in energy use as reflected in the increased numbers of automobiles, aircraft, household appliances, and an increase in both building construction activity and mechanization during the past 50 years have caused a subsequent rise in community noise levels. Social surveys have been conducted in an attempt to determine

people's attitudes and feelings concerning community noise. Borsky (1969) has identified several personal factors which influence the degree of acceptability of community noise such as: feelings about the necessity of the noise source and the value of its functions, the types of activities interfered with by the noise, other dislikes of the individual, the belief that noise can affect one's health, general noise sensitivity, and other factors including personal mobility, length of residence, and ability to adapt to a particular environmental disturbance. Noise perception amongst residents of Edmonton was assessed by a questionnaire which was conducted during the summer of 1970. This questionnaire attempted to determine people's perceptions and estimates of the occurrence of noise by identifying and evaluating the social factors outlined by Borsky. The results of this survey are discussed in Chapter Four.

The Edmonton survey was not designed to produce a statistically significant sample of residents' opinions and it has not therefore, been possible to measure correlations between the actual physical sound environment, as described in Chapter Three, and the results of the perception survey as discussed in Chapter Four. Several indices which measure individual acceptability of and reaction to the noise environment and which are based on statistically significant samples of the population have been developed. Regulatory and planning agencies are at present incorporating

some of these composite measures into their guidelines, codes, and enforcement regulations. The questionnaire is employed in this study to examine the validity of the questions asked in the social surveys used in the establishment of the above indices and to suggest other factors of individual perception which warrant consideration.

Despite the findings and recommendations of researchers who have investigated the physical and psychological influences of noise on man, noise remains a major environmental problem. A survey of present federal, provincial, and municipal legislation is presented in Chapter Five in an effort to decide why society has failed to employ and enforce the establishment of tolerable noise limits and methods of control in an increasingly noisy environment.

Chapter Six incorporates the information on noise measurement and legislation in its examination of the role of noise in urban planning.

CHAPTER TWO

NOISE MEASUREMENT

2.1. Industrial Noise Surveys

Industrial noise surveys have been conducted to investigate noise induced aural damage (Ward, 1969) and the influence of noise on the performance of the worker (Cohen, 1969). A temporary decrease in the ear's ability to detect auditory signals due to noise exposure is referred to as temporary threshold shift (TTS) and if this ability is permanently reduced the term applied is noise induced permanent threshold shift (NIPTS) (Ward, 1969). This reduction in sensitivity may take many forms including tinnitus or ringing in the ears, displacusis or shift in pitch, recruitment or shift in loudness, distortion and vertigo. TTS recovers exponentially in time and for this reason compensation commissions usually require a two week absence from the noise source before considering compensation procedures. Greater TTS can be induced by a noise with an energy concentration in the higher frequencies than a noise of lower frequency components. The noise of screeching tires, although of the same sound pressure as normal speech will be considered 'louder' by the listener because of the

difference in the frequency spectra of the two sounds. Steady state noise is more likely to produce TTS than intermittent noise. However it is caused, TTS is a biological change in the ear's mechanism which cannot be altered by the use of medications. Audiometric surveys have established <u>equinoxious</u> isolines (see Figure 2.1) which specify the maximum noise exposures per day that can be tolerated without causing TTS. Generally, the probability of hearing impairment is zero for steady state noise levels less than 80 dBA, 50 per cent for noises at a level of 95 dBA and 100 per cent probability of definite damage at the 105 dBA level (Ward, 1969, p. 44).

Noise levels that are not physically harmful may still become dangerous because they engage the hearing mechanism and reduce the ear's ability to identify other sound sensations and thereby, make the intelligibility of speech difficult. Under such conditions the warnings of a fellow worker of an impending danger may go unheeded with disastrous results. Difficulty in understanding complex instructions because of an extreme noise may result in a worker's failure to accomplish a task. The ability of noise to mask speech is a measure of the <u>speech-interference-level</u> (SIL) and is read on the decibel scale. Figure 2.2 shows the voice level required to ensure satisfactory speech intelligibility for several SIL values. An SIL value of 75 will render telephone conversation impossible and above

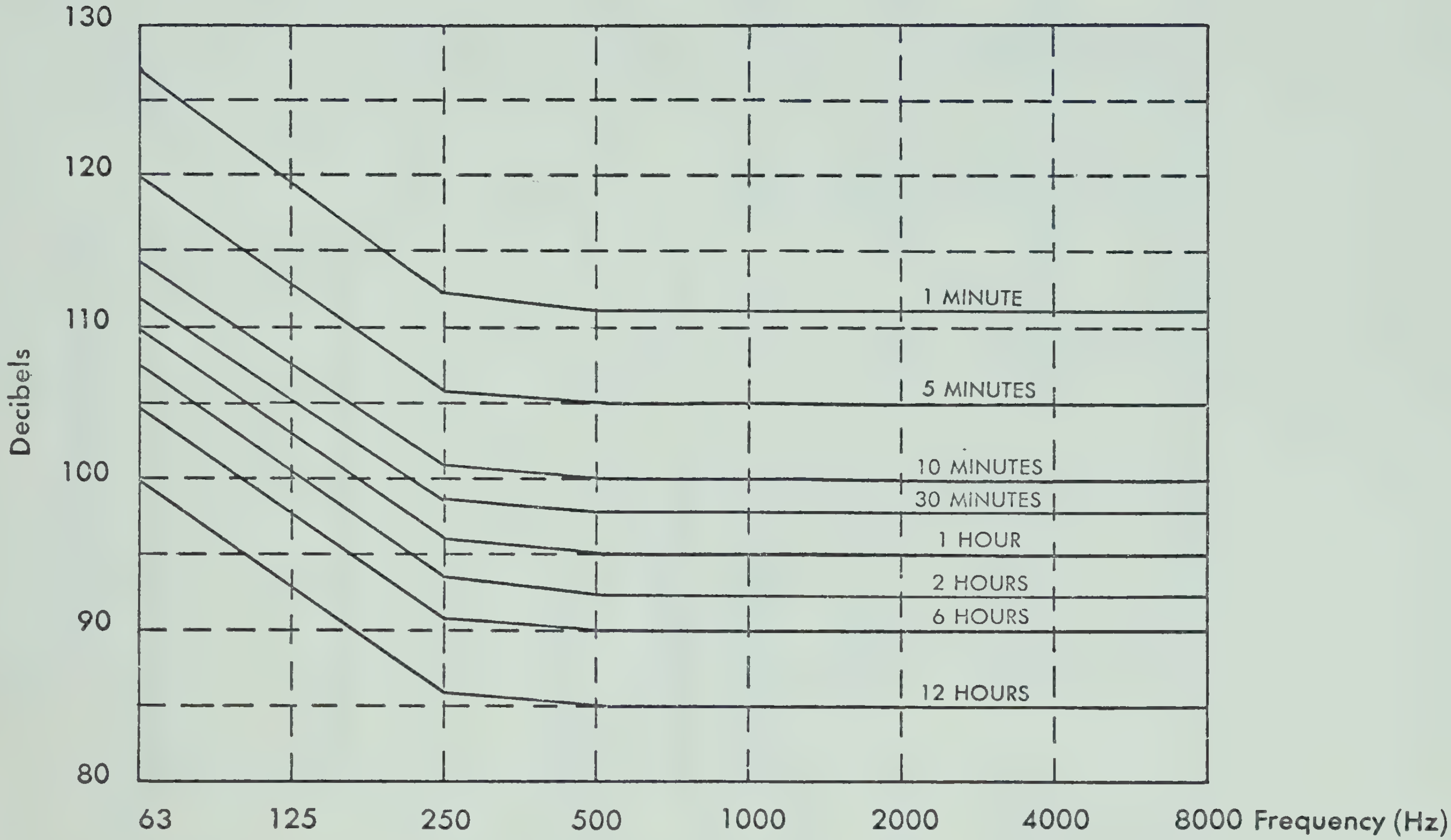


Figure 2.1 Equinoxious contours showing the maximum sound pressure levels to which workers may be exposed each day for the given time periods.

Source: *Province of Alberta, The Public Health Act, 1966, Figure 1.*

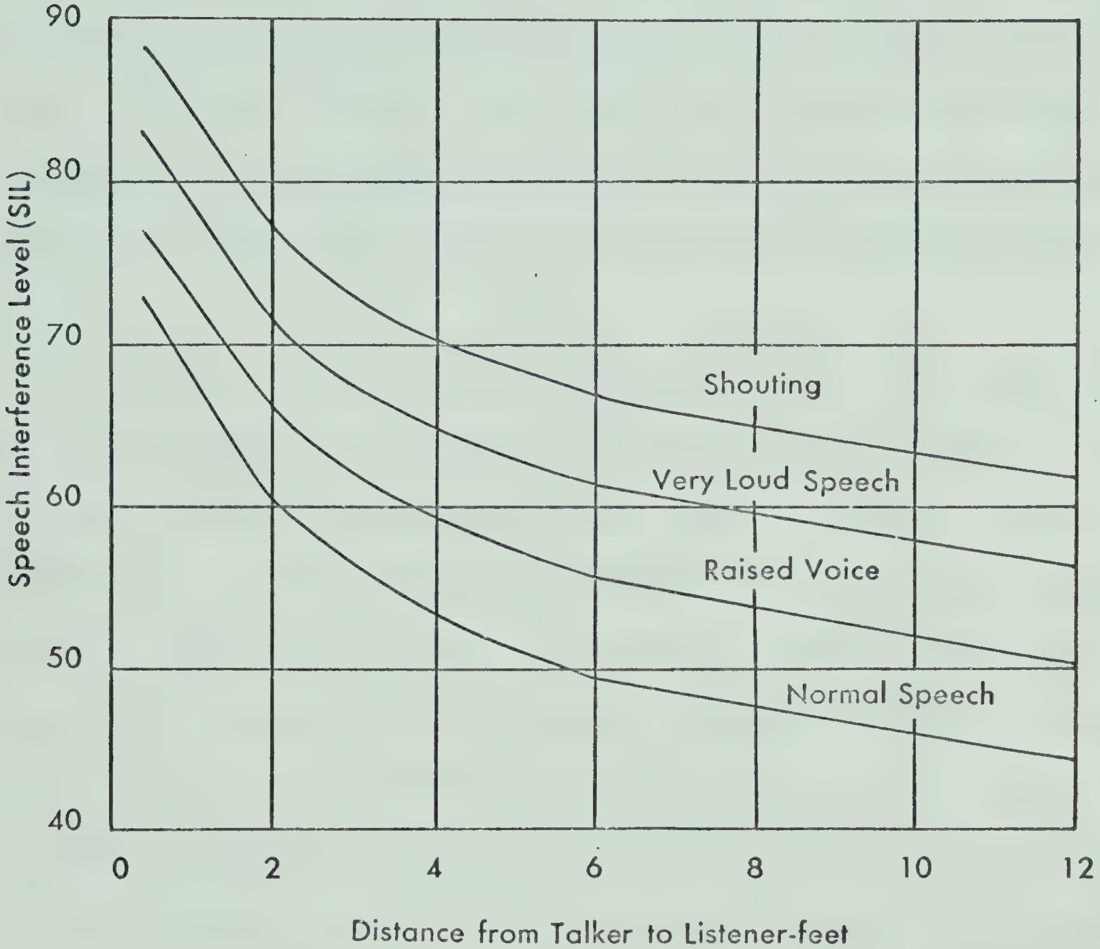


Figure 2.2 Distance and voice level requirements needed to ensure speech intelligibility for SIL values.

Source: *United States Public Health Publication No. 1572, Industrial Noise.*

90 SIL speech interference will be complete.

Noise induced physical impairment and communication disruption due to noise have been studied by industrial hygienists in order to evaluate the influence of noise on the worker's performance and ultimately to suggest noise criteria which would ensure optimal worker efficiency. Cohen (1969) has shown that noise can impair a worker's performance by causing a lapse in attention and by placing the worker under physical stress which is manifested in pain.

Levels of noise great enough to cause TTS are rare in contemporary urban areas but noise levels intense enough to cause speech interference are, unfortunately, common realities. A noise does not have to interfere with speech, however, before it may be considered noxious by the listener. The sounds of a dripping faucet, a distant scream, or a crying child, although of low sound energy, may all be extremely annoying. There are certain types of sounds and certain minimum sound levels, however, at which the majority of people become disturbed and consider the sound an unwanted feature of the environment. The two most important noise producers, in terms of maximum noise levels produced and the size of area exposed, are the automobile and the aircraft. A general understanding of noise production and propagation by these sources is essential if one is to appreciate the suggested solutions for noise

abatement.

2.2. Aircraft Noise

2.2.1. The Piston and Turbojet Engines as Noise Sources

The first commercial jet aircraft was developed by de Havilland Aircraft of England and placed in operation in 1952. Similar developments were taking place in the United States on the basis of the jet bomber and Boeing flew its first prototype commercial jet transport in 1954 (Burns, 1968). The beginning of commercial jet services was initiated with the first transatlantic flight in 1958. Community indignation with aircraft noise increased with the introduction of the jet engine. Around Heathrow Airport in London, England, the number of complaints reached a peak in the summer of 1960, although since that time the actual number of complaints have increased at a lesser rate than the rate of increase in annual aircraft movements (Committee on the Problem of Noise, 1963). This widespread annoyance which was coincidental with the introduction of jet transport has been attributed to the unfamiliarity of the jet noise as well as to the more intense sound level of the jet engine as compared to the piston engine (Burns, 1968). Since the early 1960s jet noise has become all too familiar and the greater number of occurrences of jet noise is now the main cause of annoyance. The difference in noise characteristics of piston and jet engines may be explained by

a short description of the two engines as noise producers.

The piston engine generates most of its noise in the exhausts and the propellers (Burns, 1968). Figure 2.3 illustrates how the characteristic 'rumble' of the piston engine is due to the sound energy being concentrated in the lower frequency range.

The jet engine, which produces greater power than the conventional piston engine, operates on quite different principles. Jet propulsion is a force exerted by hot, high velocity gases which are produced by the burning of fuel within the engine. The oxygen used in the burning is obtained from the atmosphere, unlike a rocket which acquires its oxygen from a self-contained supply. The air is taken into the engine and is compressed and in conjunction with fuel combustion hot gases are produced which expand and drive the turbine. The turbine, in turn, drives the compressor. The characteristic 'whine' or high frequency squeal of the jet engine is due to the forward noise created by the compressor system. Violent mixing of the exhaust gases with the atmosphere produces the jet 'roar'. If the exhaust velocity is greater than the ambient or environmental speed of sound, a shock wave will form. This phenomenon is called Mach wave radiation and is observed in solid bodies moving at supersonic speeds. Both the supersonic transport (SST) and air particles moving from a subsonic jet at speeds greater than the speed of sound create shock

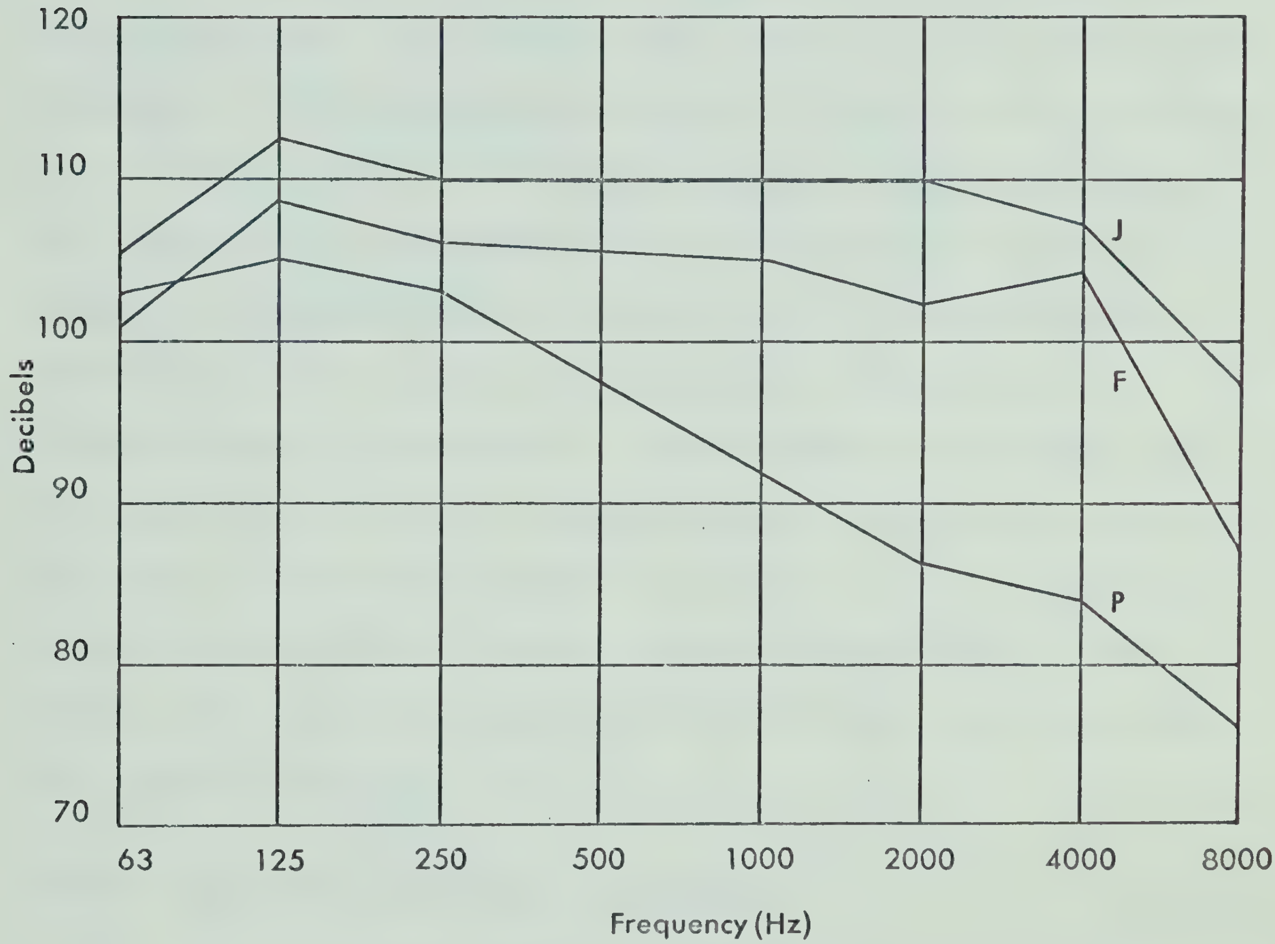


Figure 2.3 Frequency spectra of three aircraft types in flight. J, Turbojet; F, Turbofan; P, four-engined propeller aircraft with piston engines.

Source: *W. Burns, 1968, p.210.*

waves. The latter case may be found in the conventional jet engine and at present the significance of such Mach wave radiation in terms of human reaction has not been fully evaluated (Hubbard et al., 1967).

The turbofan engine was developed to reduce exhaust noise by allowing some of the compressed air to bypass the combustion area. This engine has enabled a 10 to 12 decibel decrease in jet noise at the exhaust (Committee on the Problem of Noise, 1963, p. 66) by lowering the gas velocities. The directional characteristics of the jet and the fan or bypass engines are shown in Figure 2.4. The differences between the two engines are significant factors in the determination of annoyance. The turbofan by creating less rearward noise than the turbojet is quieter during take-off but due to increased forward compressor noise the turbofan is noisier during the landing phase (Burns, 1968). The Boeing 737, which is examined in this study, has two turbofan engines (Appendix III).

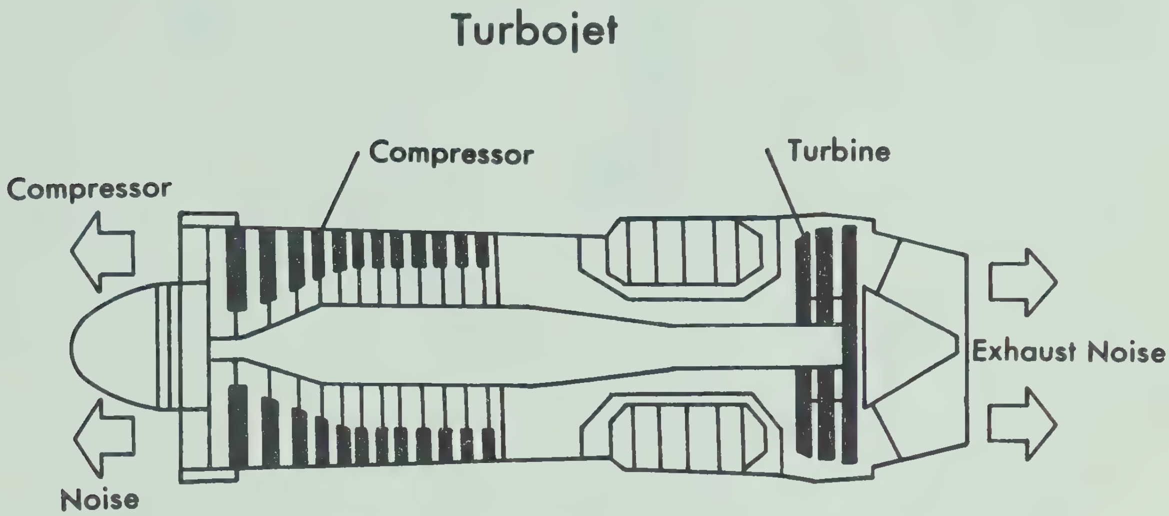
2.2.2. Aircraft Operating Procedures

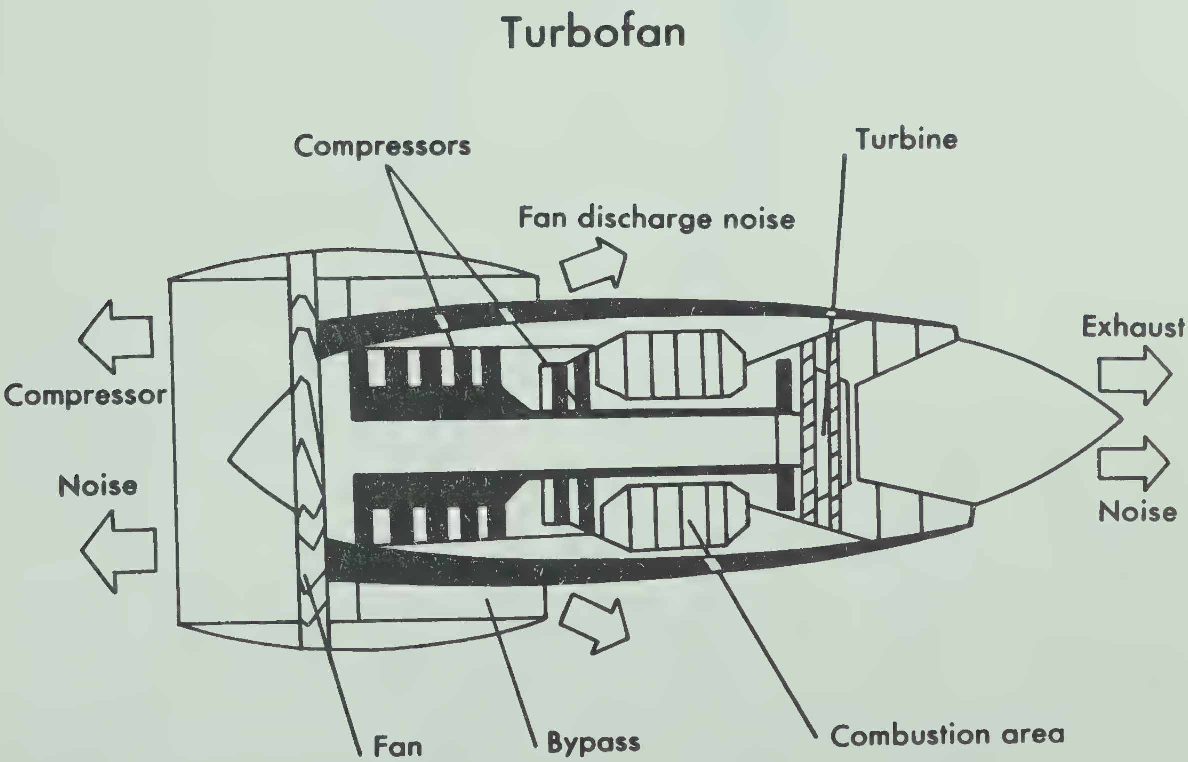
Aircraft operating procedures are significant factors in evaluating aircraft noise. These procedures are classified as landing, taking-off, and ground running operations.

During the landing procedure the average approach slope of the aircraft is 3° from the horizontal as shown in Figure 2.5. Approach slopes steeper than 3° are usually

Figure 2.4

Diagrammatic sections of a turbojet and a turbofan engine showing sources of noise





Source: Burns, 1968 and Hubbard et al., 1967

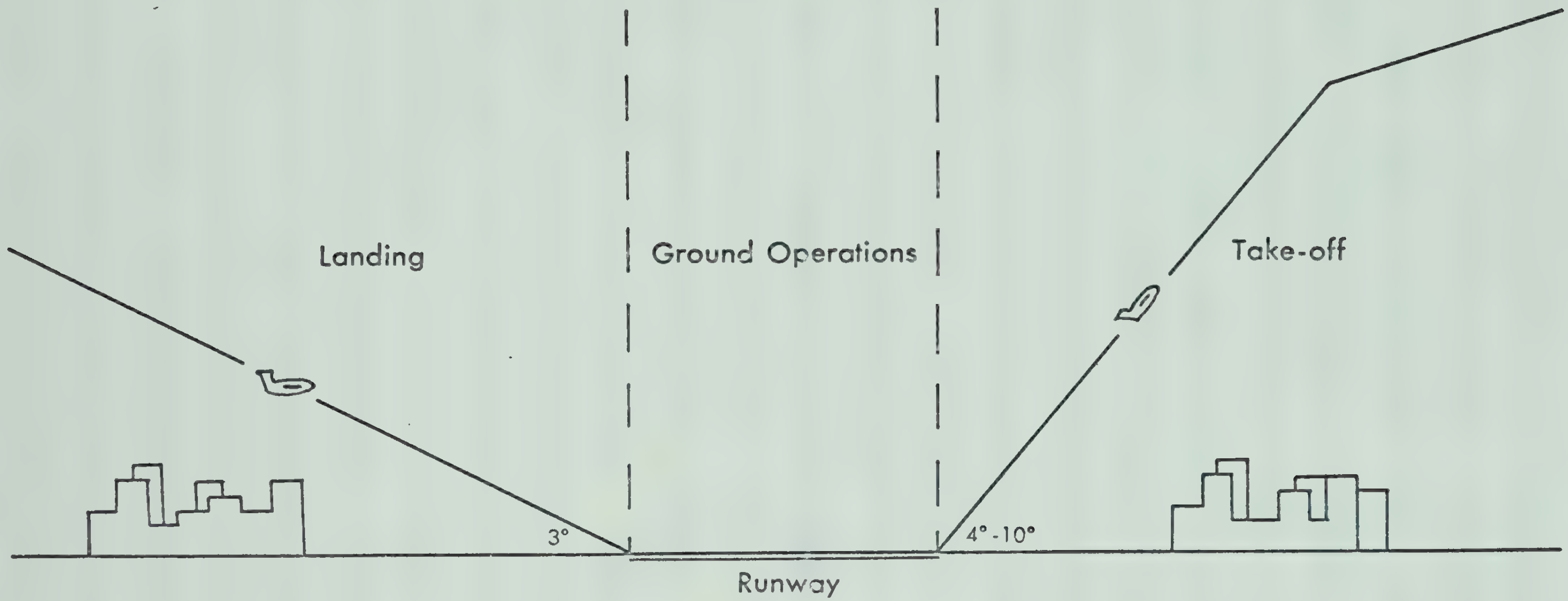


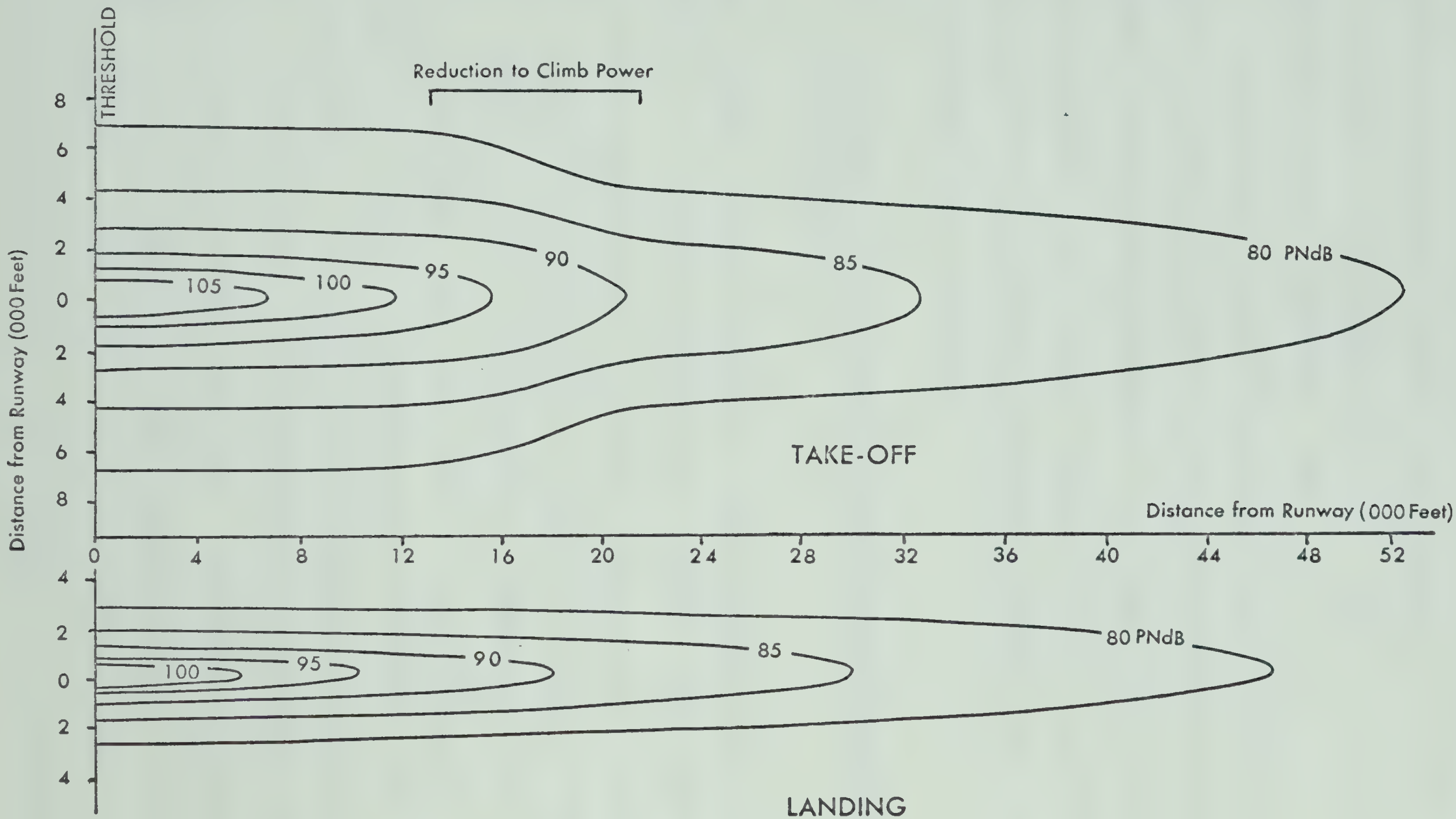
Figure 2.5 Aircraft operations which result in noise in communities near airports.

Source: H. Hubbard et. al., 1967, p.377.

prohibited because the inability to successfully manoeuvre the aircraft increases with the steepness of approach. (The development of the vertical take-off and landing (VTOL) and short take-off and landing (STOL) aircraft have brought a new vista to airport planning because of the steeper approach and take-off slopes that can be utilized. The implications of these new aircraft to future air transport development are discussed in Chapter Six.) During this shallow approach procedure the engines are operating at reduced engine power and consequently the noise does not extend as far laterally from the flight path as during take-off when the engines are operating at maximum power.

Take-off slopes are steeper than landing slopes because of the larger thrust-to-weight ratio which implies an engine working at maximum power capacity and evidently, at maximum noise producing capacity. Take-off slopes vary from 4° to 10° depending on the type and weight of the aircraft. The fact that an aircraft taking-off will be at a higher altitude than a landing aircraft at unit distance from the runway would be expected to result in a lower ground noise level from the aircraft taking-off. However, the greater power of the aircraft taking-off as a noise producer outweighs the difference in the source-listener distance and Figure 2.6 shows how the take-off <u>noise foot print</u> is much larger in area than the landing noise foot print. Because a landing aircraft is closer to the ground

Figure 2.6 Perceived noise level contours for take-offs and landings of two engine propeller transport aircraft.



Source: Bolt, Beranek and Newman, Inc., Appendix 'A', May 1965.

than one taking-off and because of the tilt of the aircraft, landing noise from the intake compressors (a whine) may be more annoying to a listener than the 'roar' of the exhausts during the take-off (Beranek, 1969).

Disturbing aircraft noise may also exist where the aircraft is being operated on the ground for maintenance purposes. During this procedure the engine may be operated at maximum thrust for several minutes and if sound barriers are not provided, serious community annoyance may arise in the vicinity of the airport.

2.2.3. Discussion of Aircraft Noise Surveys and Definition of Study Area

In April 1960 the British government established a committee "to examine the nature, sources, and effects of the problem of noise and to advise what further measures can be taken to mitigate it" (Committee on the Problem of Noise, 1963, p. xii). This committee made its final report in July 1963 which forms the basis of much European legislation that has since been enacted or is presently in a state of preparation. Personnel from the Ministry of Aviation measured aircraft noise at 85 locations throughout all residential districts within ten miles of Heathrow Airport, London. These 85 locations were specifically chosen in order to estimate the noise environment for each of 1,731 randomly chosen residents. In addition, 178 residents who

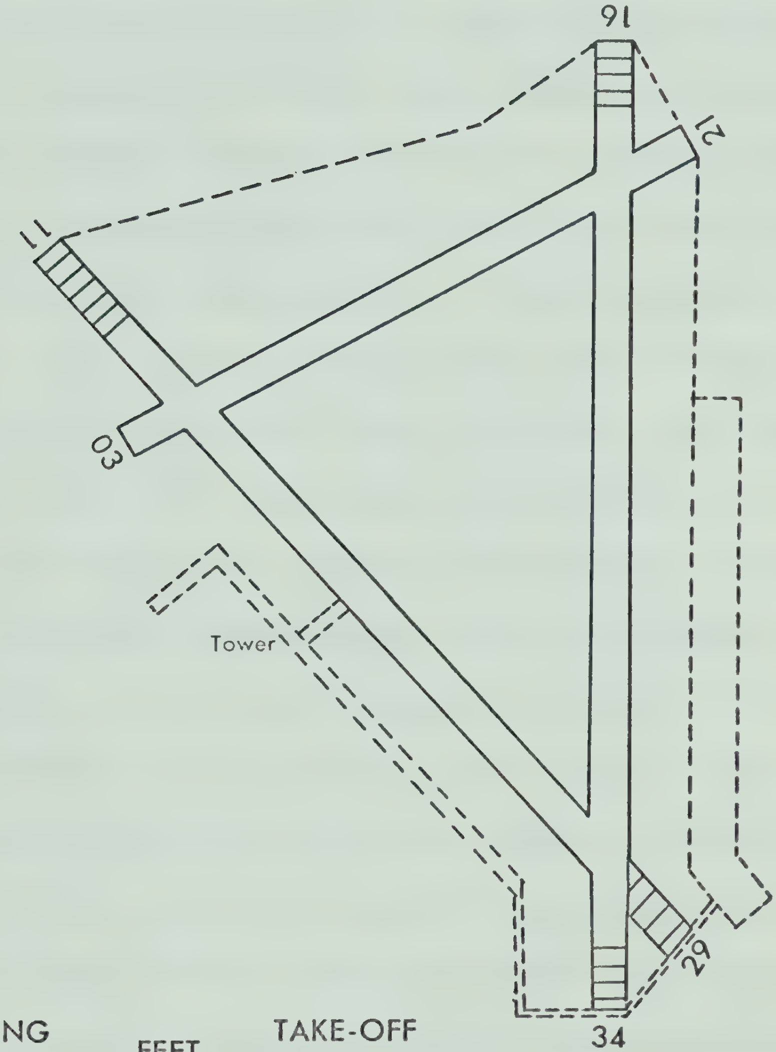
had complained about aircraft noise were interviewed. At each location noise from about 100 aircraft was recorded for later analysis which supplied such information as the peak noise levels, the noise level exceeded by 10 per cent and by 50 per cent of the aircraft, and the number of seconds during which 85 PNdB and 95 PNdB were exceeded. This information was then employed in developing a sociological index for describing the annoyance level of a community.

Rather than measuring aircraft noise at a location determined by the presence of a chosen listener this thesis examines the noise in relation to the source. By measuring noise at locations along the flight path a noise contour or noise foot print, similar to Figure 2.6, can be constructed to show the noise environment below either an aircraft taking-off or landing. The International Organization for Standardization (ISO) prepared a recommendation in 1964 establishing the procedure for measuring and describing the noise exposure in the vicinity of an airport (Ingerslev, 1966). Major measurements must be made with internationally standardized sound measuring equipment. At a site vertically below the aircraft flight path the peak noise level and duration of the noise are measured by a sound level meter and transferred to magnetic tape for later octave band analysis. Additional required information includes aircraft gross weight on take-off, engine power, air temperature, head-wind component, time of day and season of

year. The noise data are standardized to a temperature of 15°C and a relative humidity of 60 per cent and any reading requiring a correction greater than 10 dB must be rejected. The physical noise data are computed into perceived noise levels (PNdB) and contours of equal maximum perceived noise are drawn over a map of the airport environs. The decision that a noise is disturbing or annoying not only depends on the PNdB level but also on such factors as frequency of aircraft flights over a particular location each day, the time of day, and the length of time a certain noise level such as 85 PNdB is exceeded. Obtaining the basic noise foot print for an airport such as the Edmonton Industrial Airport is not feasible for one researcher with limited equipment and limited access to information about the weight, power settings, and other operational specifications. Rather, the noise contours used in this study have been developed by the aircraft manufacturers. Sound measuring equipment (see Appendix II) was used to assess the applicability of these contours to the Edmonton situation.

The Edmonton Industrial Airport has six runways, 16, 34, 11, 29, 03, and 21, as shown in Figure 2.7. Runway 34 or the south-to-north runway is equipped with an instrument landing system (ILS) which consists of a radio and light beacon angled at 3° from the horizontal to ensure a safe approach angle. The instrument approach zone is

Figure 2.7 Runway Layout at Edmonton Industrial Airport



LANDING RUNWAY	FEET	TAKE-OFF RUNWAY
03	3776	21
11	5068	29
16	5190	34
21	4296	03
29	4681	11
34	5160	16

Source: Canada Department of Energy, Mines, and Resources, Edmonton Aeronautical Map, 1969.

triangular in shape (see Figure 2.8) with the apex centered on Runway 34 and the base, approximately three miles in width, located on the southern city limits. The take-off zone is smaller in area than the approach zone. Although a particular aircraft's take-off or approach paths may not be confined to these zones because of prevailing winds, the aircraft manufacturers who developed the noise foot prints assumed ideal wind conditions and constant angles of take-off and approach. Such assumptions are included in this study. Data on the time of day of each flight and the runway used were collected for June, July, and August 1970. The following information was thus made available with which to compute the Composite Noise Ratings for Edmonton; peak decibel level of aircraft noise for any point in Edmonton (measured in PNdB), the aircraft operation (take-off or landing), the type of aircraft, the time of each overflight, and the number of overflights.

The PNdB has been accepted internationally in order to "provide legislative and regulatory bodies and manufacturers and aircraft operators with a common quality" (Beranek, 1969, p. 256). The CNR is a sociological index which was developed in the United States during the early 1960s and is an evaluation of the influence of the number of aircraft overflights and the time of day of the noise on the human response to aircraft noise and is measured on the PNdB scale. Because it examines factors other

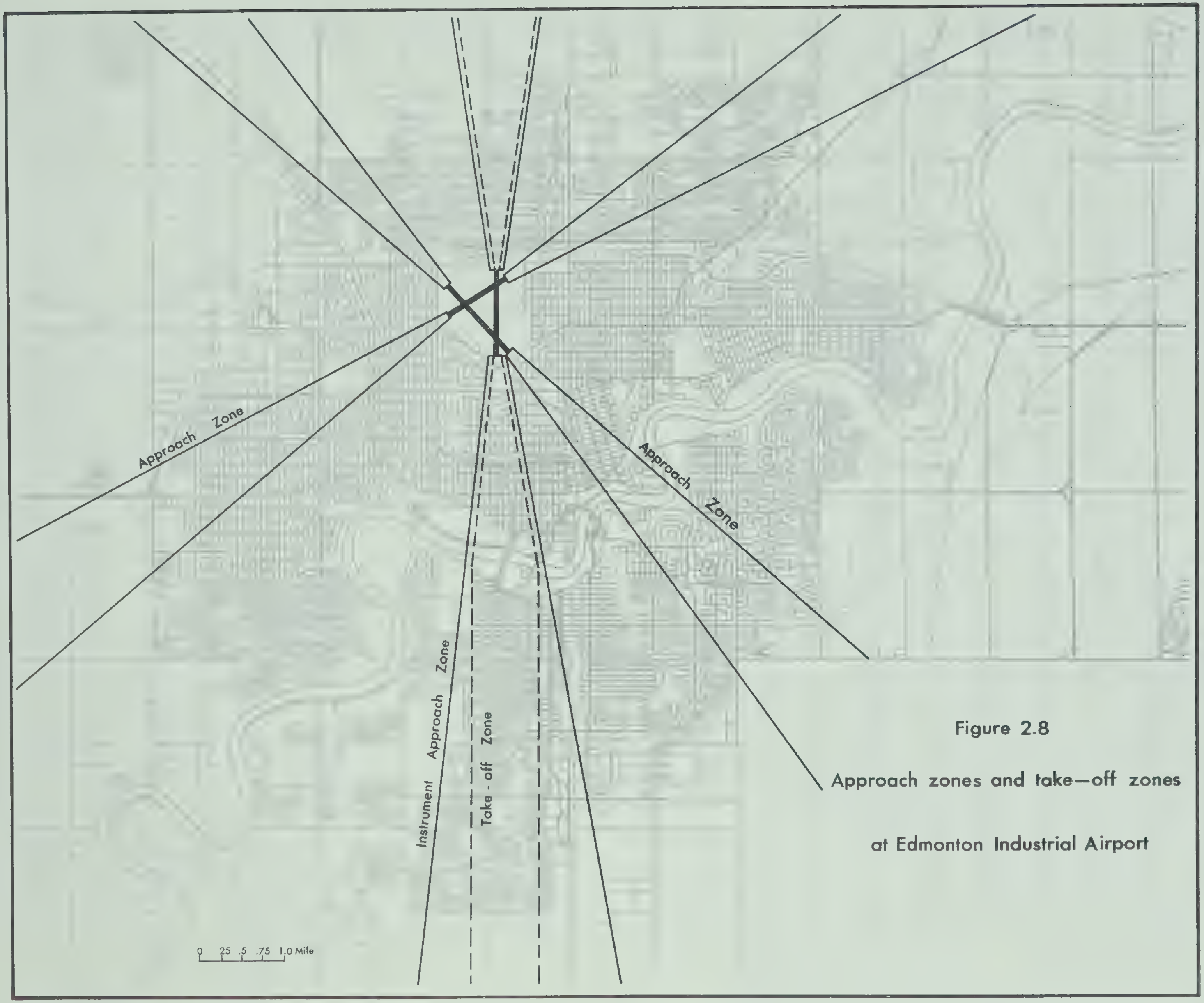


Figure 2.8

Approach zones and take—off zones

at Edmonton Industrial Airport

than just the noise level, the CNR represents a more useful tool than basic PNdB information. Other sociological indices which have been developed include the British Noise and Number Index and the German Q Factor which are both based on detailed noise research and sociological surveys. The Aviation Planning and Research Division of the Federal Ministry of Transport, provincial planning authorities, such as the Ontario Municipal Affairs Branch, and the Central Mortgage and Housing Corporation have accepted the CNR for control and planning purposes because of the feeling that the factors used in the calculation of the CNR more closely reflect the Canadian social scene than the European based indices. The significance of the CNR is shown by the fact that the Central Mortgage and Housing Corporation is at present redefining its lending requirements around airports with respect to CNRs.

2.3. Motor Vehicle Noise

The aircraft is one of today's main sources of noise but the most pervasive of urban noises is that of the automobile. Although automobiles are not as powerful and therefore, not as noisy as aircraft, automobiles greatly outnumber aircraft and a much wider area is exposed to motor vehicle noise than aircraft noise. Motor vehicle noise is not as confined as that of aircraft and consequently its area of influence is much more random as

compared to the symmetrical noise foot print of an aircraft.

Motor vehicle noise is so common a fact in urban areas that the ambient or background noise is largely due to such vehicles (Burns, 1968, Dunsbee and Billingsley, 1967, and Olson, 1970). Purkis (1964) found that at 84 per cent of the sites in the London Noise Survey, undertaken by the Committee on the Problem of Noise, the noise levels were attributable to traffic noise. The differences between the propagation by and spatial extent of motor vehicle and aircraft noise must be recognized when evaluating noise for planning purposes. Also, an understanding of motor vehicle noise will contribute to an understanding of how the ambient or background noise due to motor vehicles affects the perception of aircraft noise.

The automobile engine is a water or air-cooled, high compression engine enclosed within a metal shielding. The existence of a compartment or body enables a significant amount of attenuation of mechanical noise to be gained. The main noise sources are the exhaust and openings in the bottom of the compartment (Denby, 1967 and Thiessen, 1969b). The speed and condition of the engine affect the noise production and both of these factors are under the direct control of the driver. Gear noise is minimal in passenger cars but may attain considerably higher levels in trucks working under a heavy load. The pneumatic brake system employed in heavy trucks represents a source of high frequency noise. Tire noise is a major problem in trucks

and research is presently being conducted to design a tire tread and road surface with maximum attenuation characteristics (Thiessen, 1969b).

2.3.1. Motor Vehicle Noise Surveys

The level of traffic noise is determined by the frequency of occurrence of the noise or the number of motor vehicles and the level of noise emitted by the individual vehicles. Ten cars passing a house in one hour will be less disturbing than 100 cars of similar character passing that site in one hour. However, ten cars without mufflers or noise suppressors may create a more noxious environment than 100 muffled cars. Stopping and accelerating also create more noise than operating at a constant speed and in addition, prolong the time during which the noise is present. Authorities interested in reducing traffic noise therefore have several approaches from which to attack the problem. Legislative control on the amount of permissible noise can be instituted and techniques of increasing traffic flow such as the use of grade separations and traffic re-routing from residential streets to selected throughways will contribute to a greater degree of control over, if not an actual reduction in, the noise.

Two different types of noise surveys have been developed to investigate urban traffic noise. One type of survey measures the noise of several types of motor

vehicles under different but controlled operating conditions while the other method measures the noise levels in different residential areas and along different types of traffic routes in order to assess the influence of traffic on the total noise environment. The results from this field survey method form the basis of planning decisions because they describe the real living environment. However, information gleaned from the controlled experiments is important in evaluating the actual noise situation.

The procedure for measuring motor vehicle noise under controlled conditions is outlined in the ISO regulation R362 and is adhered to in the Acoustic Section of the National Research Council of Canada (Olson, 1970). In this procedure a test site is selected along a traffic route where there are no buildings or other obstructions within at least 50 metres of the measuring equipment and vehicles are driven past the site at prescribed speeds and rates of acceleration by skilled drivers. These controlled experiments enable the acoustician and engineer to develop noise suppression designs which can then be introduced into the manufacturing process of the vehicle. Faulty machinery and unskilled operators are excluded in this procedure because these factors cannot be controlled by the manufacturer.

During 1970 the National Research Council recorded and analyzed noise from approximately 2500 vehicles as part of a study investigating the noise environment of Ottawa

(Olson, 1970). A microphone was placed 50 feet from the centre of the traffic lane and about 4 feet above the pavement level. The sound level meter which can measure noise on the A, B, C or linear scale was placed on linear response. This procedure enabled the noise to be later analyzed in the A, B, and C frequency weightings whereas an initial A-weighting measurement would have restricted the analysis to dBA. (The transfer of the noise from magnetic tape to graph paper is explained in Appendix II and Figure 2.9 is a typical recording trace of a passing truck.) A radar speed meter was employed and speeds were classified into four ranges, 30 - 39, 40 - 49, 50 - 59, and 60 - 69 m.p.h. Vehicles were grouped into passenger cars, dump trucks, buses, and tractor trailers. Figure 2.10 compares the ranges of noise for several types of vehicles travelling at different speeds. Such information on the noise capabilities of different types of vehicles under different operating conditions can be used to attenuate traffic noise by designing speed limits and optimum routes for each vehicle. From Figure 2.10 it is apparent that if empty dump trucks must travel past a residential area then a noise level comparable to that of passenger cars may be achieved if the trucks travel at lower speeds than the cars. The lower truck speeds should be attained before reaching the residential area and maintained, if possible, throughout the area in order to eliminate noise arising from the gear

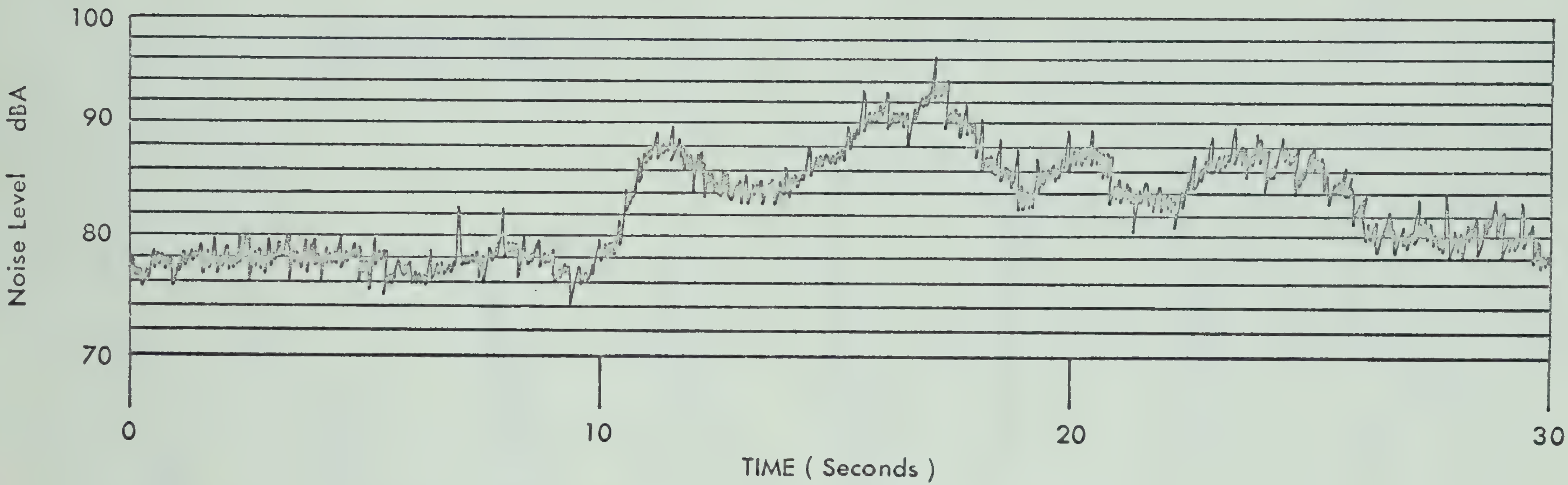
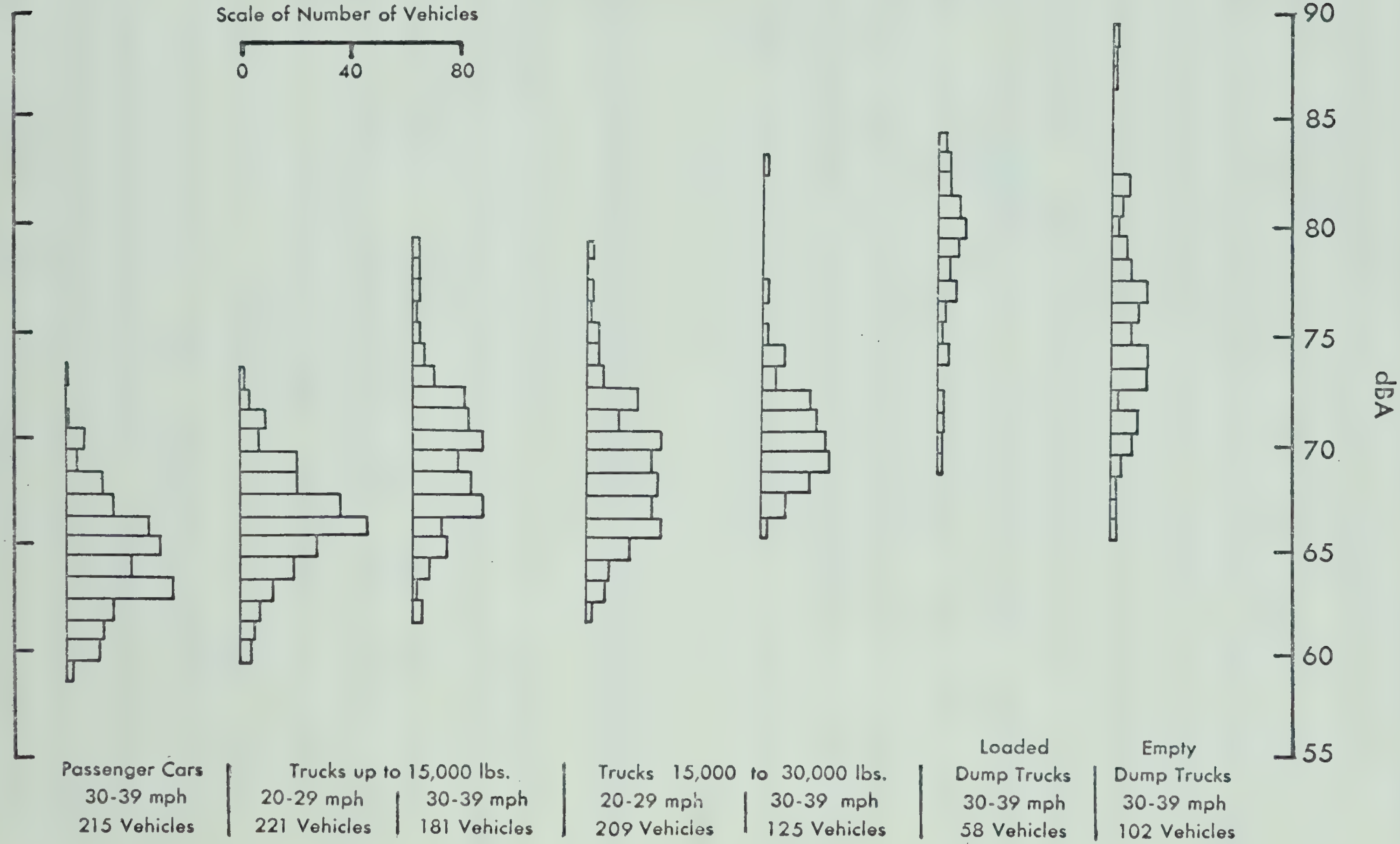


Figure 2.9 Typical recording of a passing truck (30-39 mph) measured from 25 feet.

Figure 2.10 Comparison of ranges of noise produced by different types of vehicles travelling at different speeds.

Source: N. Olson, Statistical Study of Traffic Noise, 1970, Figure 20.



changes and braking procedures.

To relate the test site findings to practical noise abatement problems a field survey was completed in which five sites were selected within Ottawa and the ambient noise levels measured over a 24 hour period. The test sites ranged from a downtown hotel located beside a multilane traffic route to a residential area with streets carrying only local traffic. The decibel levels at which 10 and 90 per cent of the sampling time was exceeded were then determined. The sound which prevailed between these two levels or, for 80 per cent of the time, is defined as the noise climate and the range of the noise climate for the different sites was found to be directly related to the amount of traffic.

2.3.2. Noise Recording Procedure Used in Edmonton Survey

Automatic recording equipment capable of measuring sound levels over a 24 hour period was not available for use in this study. Rather, three periods of the day, morning (0800 to 1000 hours), afternoon (1500 to 1700 hours), and evening (2100 to 2300 hours), were designated and a sampling time of 15 minutes for each period was made. This technique has been used by Bruel and Kjaer, Danish sound equipment manufacturers (Broch, 1969). Twenty-one sites were selected within Edmonton and are shown in Figure 2.11. Seven sampling points, one mile apart, were located along the centre of approach to Runway 34. Sites 1/4 mile east

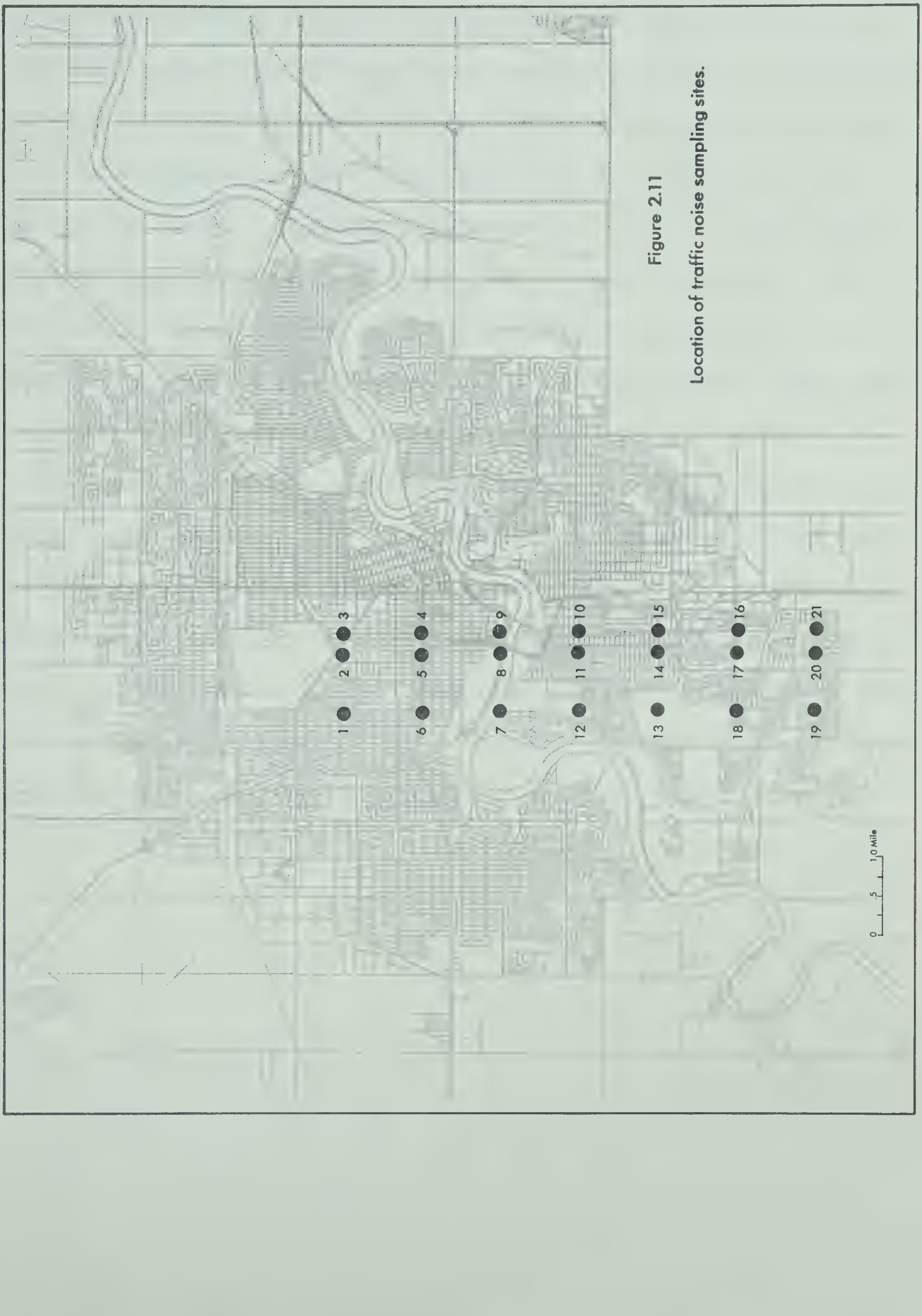


Figure 2.11

Location of traffic noise sampling sites.

and 3/4 mile west of each of the centre points were then located. These sites range from quiet residential areas to multilane traffic arteries. Analysis of the sound levels was made using the dBA scale, a scale accepted by legislators as being most meaningful in developing noise abatement criteria because it best approximates the human ear's response to sound. Since Robinson et al. (1963) have found that PNdB can be converted to dBA values, the use of the dBA scale in measuring traffic noise allows aircraft and traffic noises to be compared on a common scale. This fact together with locating the sampling points in relation to the aircraft landing and take-off zones enables an examination to be made of the influence of the ambient noise level on the perception of aircraft noise. The applicability of these objective measures in describing the urban environment is examined by interviewing residents living near each of the sampling sites. The following chapter presents the results of the aircraft and motor vehicle noise surveys.

CHAPTER THREE

THE NOISE ENVIRONMENT OF EDMONTON

3.1. The Aircraft Noise Environment of Edmonton

As was shown in Chapter Two, the noise level of an aircraft as measured on the ground depends on the type of aircraft and the type of operation. Jet noise is differently perceived by a listener than piston noise and the level of noise produced differs between the landing and take-off phases. In Figure 3.1 it may be observed that perceived jet noise at any particular sound pressure level is greater in areal extent than piston aircraft noise of the same sound pressure. This is attributable to the higher frequency components of the jet noise which cause the human ear to perceive that noise as 'louder' or 'noisier'. The larger spatial extent of the jet noise is also related to the greater power of that engine as compared to a piston engine. The tracings in Figure 3.2 of jet and piston noise were made at the same location and on the linear or dB scale there appears to be little difference in sound pressure between the two noise sources. However, when the two noises are analyzed on the A-network (dBA) the influence of high frequency components in the jet noise is indicated

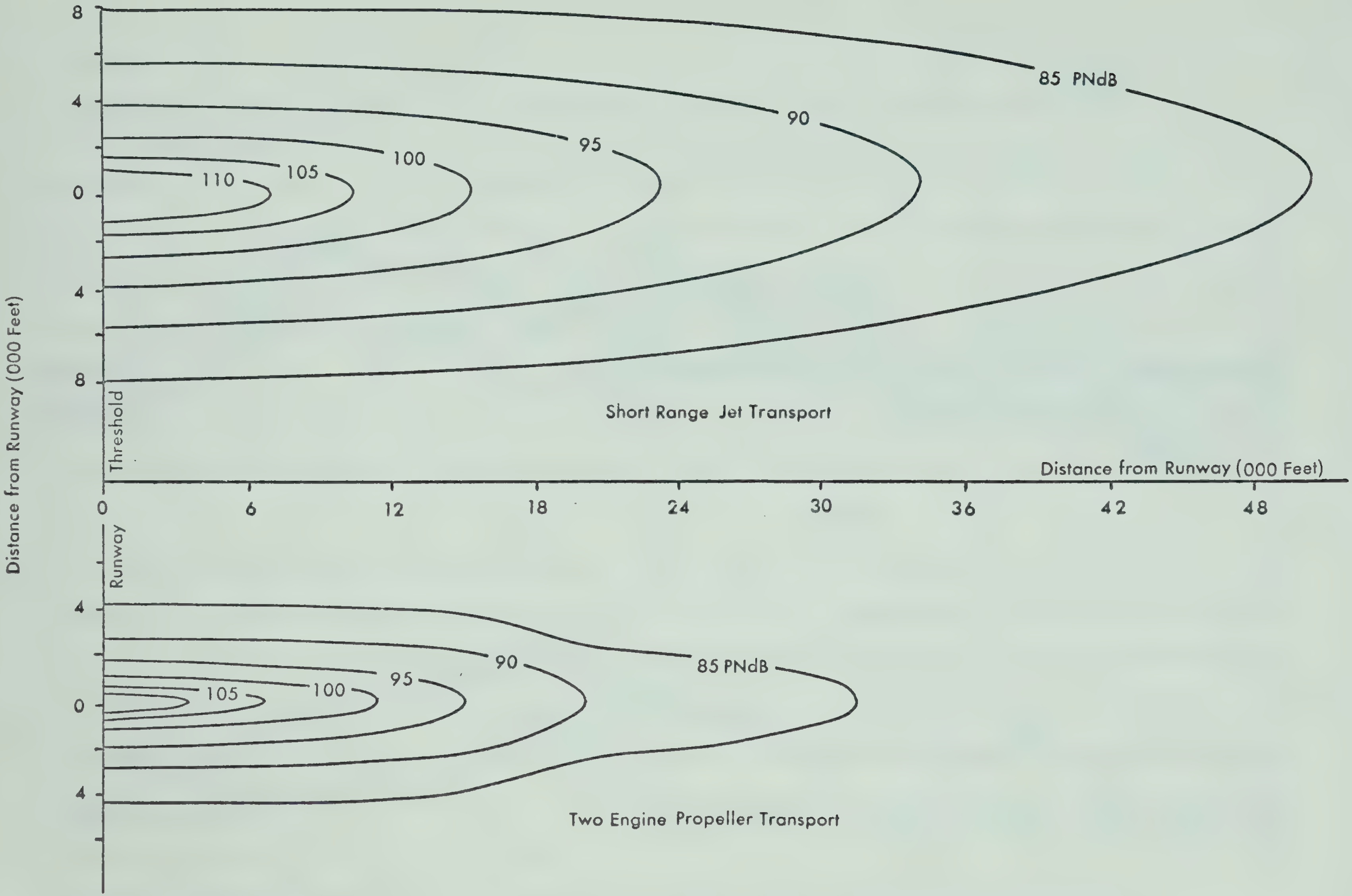
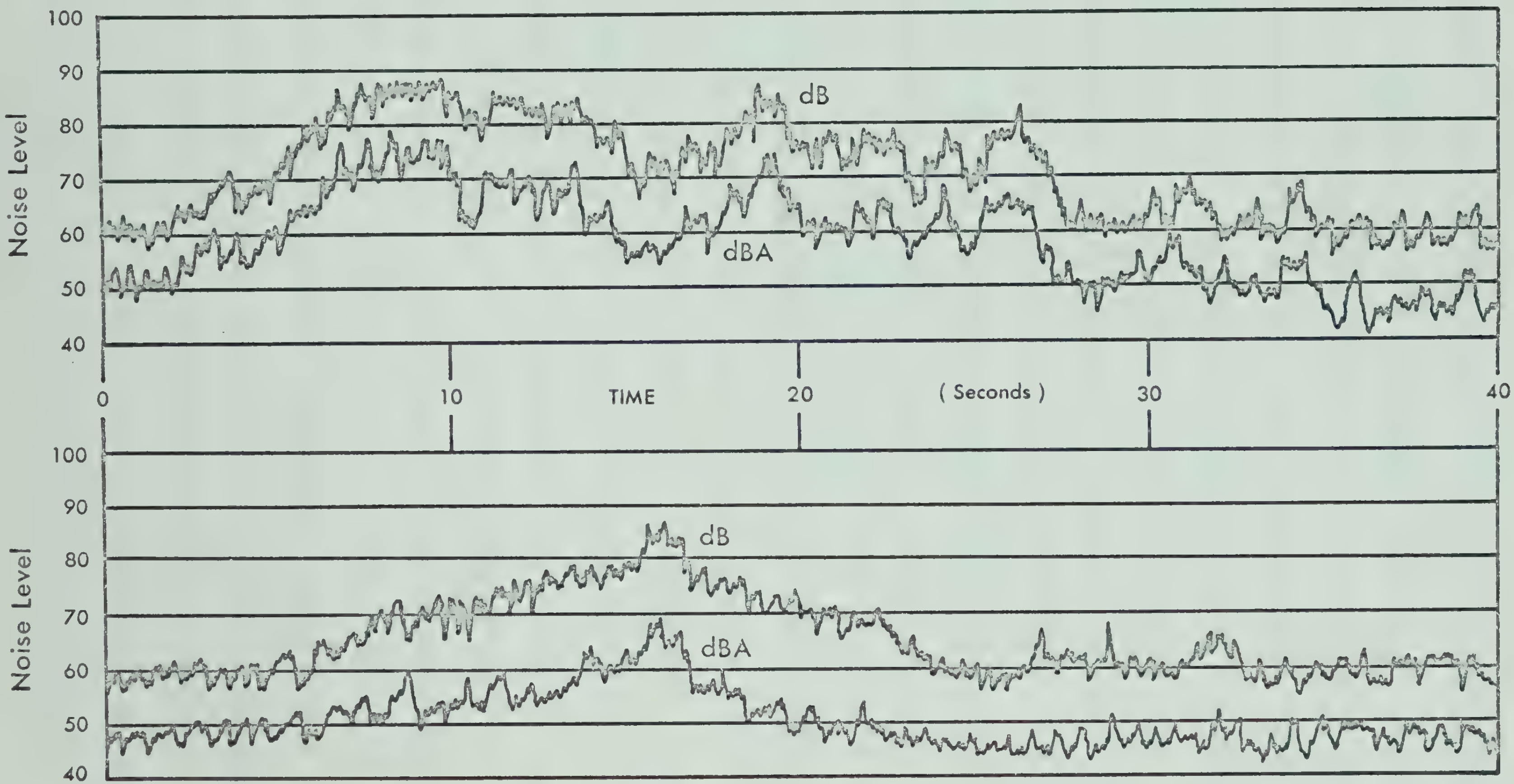


Figure 3.1 Perceived noise level contours for short range jet transport and two engine (piston) propeller transport aircraft (TAKE-OFF). Source: Bolt, Beranek and Newman, Inc., Appendix 'A', May 1965.

Figure 3.2

A. Sample noise level time history for the take-off of a turbofan engine aircraft (Boeing 737) observed at Location 8.



B. Sample noise level time history for the take-off of a piston engine aircraft (Douglas DC-3) observed at Location 8.

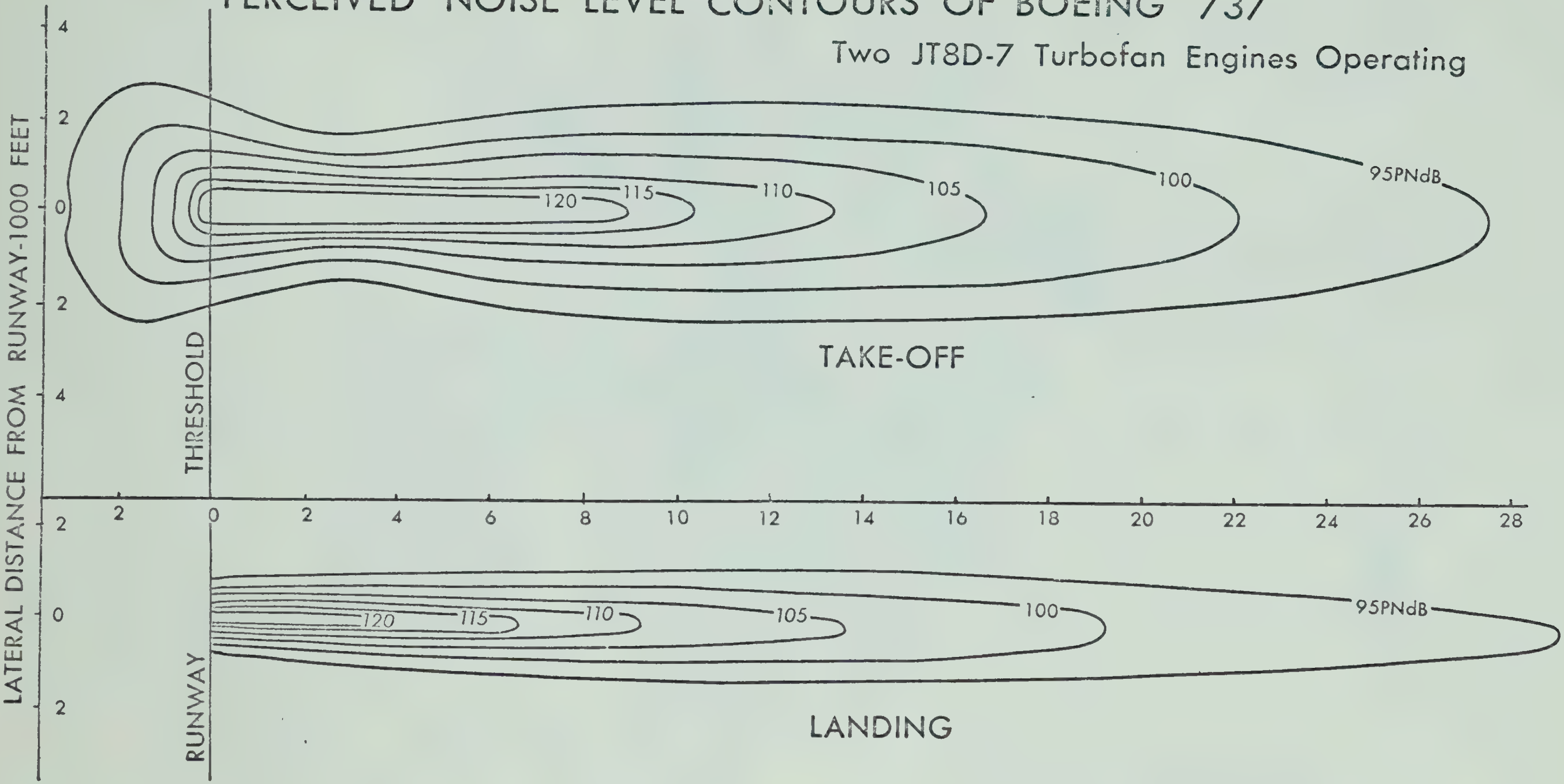
where the jet noise is shown to be louder than the piston noise.

The perceived noise level contours for the Boeing 737 are shown in Figure 3.3 and in Figure 3.4 these contours are applied to the Industrial Airport to indicate the extent of take-off jet noise within the city of Edmonton. The noise foot prints were not applied to Runways 03 and 21 because they are too short to enable Boeing 737 utilization. Figure 3.4 represents a quantitative estimate of the loudness level of the jet noise. However, in an earlier discussion it was noted that the actual physical noise level or decibel level of an aircraft engine is not a realistic description of how that noise is perceived by an individual. A listener subjected to 10 overflights of an aircraft each day will perceive the aircraft noise environment differently than a listener subjected to 100 overflights during that same time period. (Many other sociological factors influence the final reaction to noise, a fact which one must be aware of when applying physical and objective measurements to planning decisions.) The use of a particular runway and hence the area of the city exposed to the noise depends on the prevailing wind conditions or head-wind component. The percentage utilization of the runways at the Industrial Airport for Boeing 737 operations during the summer of 1970 is shown in Figure 3.5. From this figure it is apparent that certain areas of the city were exposed to more aircraft

FIGURE 3.3

PERCEIVED NOISE LEVEL CONTOURS OF BOEING 737

Two JT8D-7 Turbofan Engines Operating



THE BOEING COMPANY SEATTLE, WASHINGTON OCTOBER 1968.

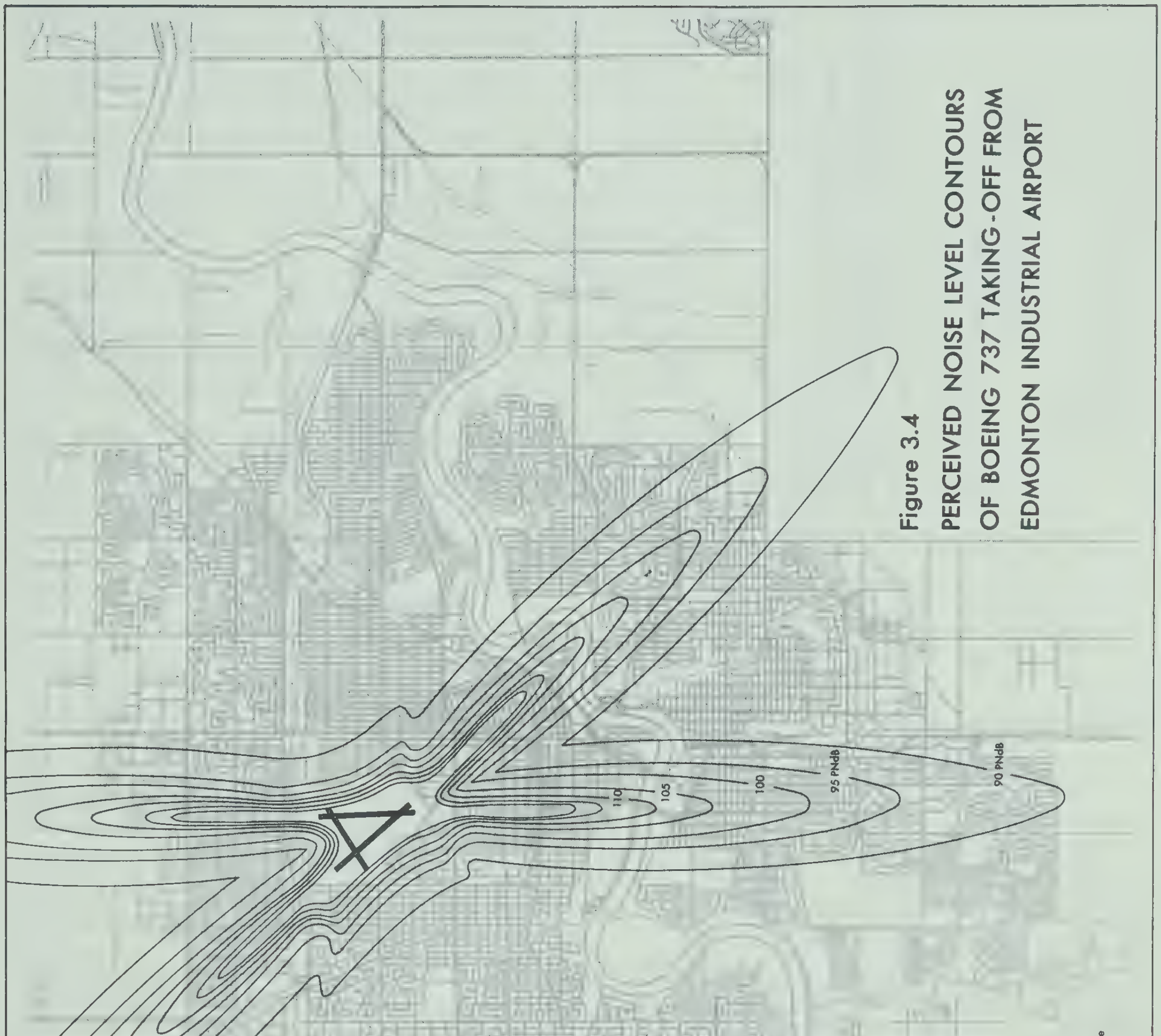


Figure 3.4
PERCEIVED NOISE LEVEL CONTOURS OF BOEING 737 TAKING-OFF FROM EDMONTON INDUSTRIAL AIRPORT

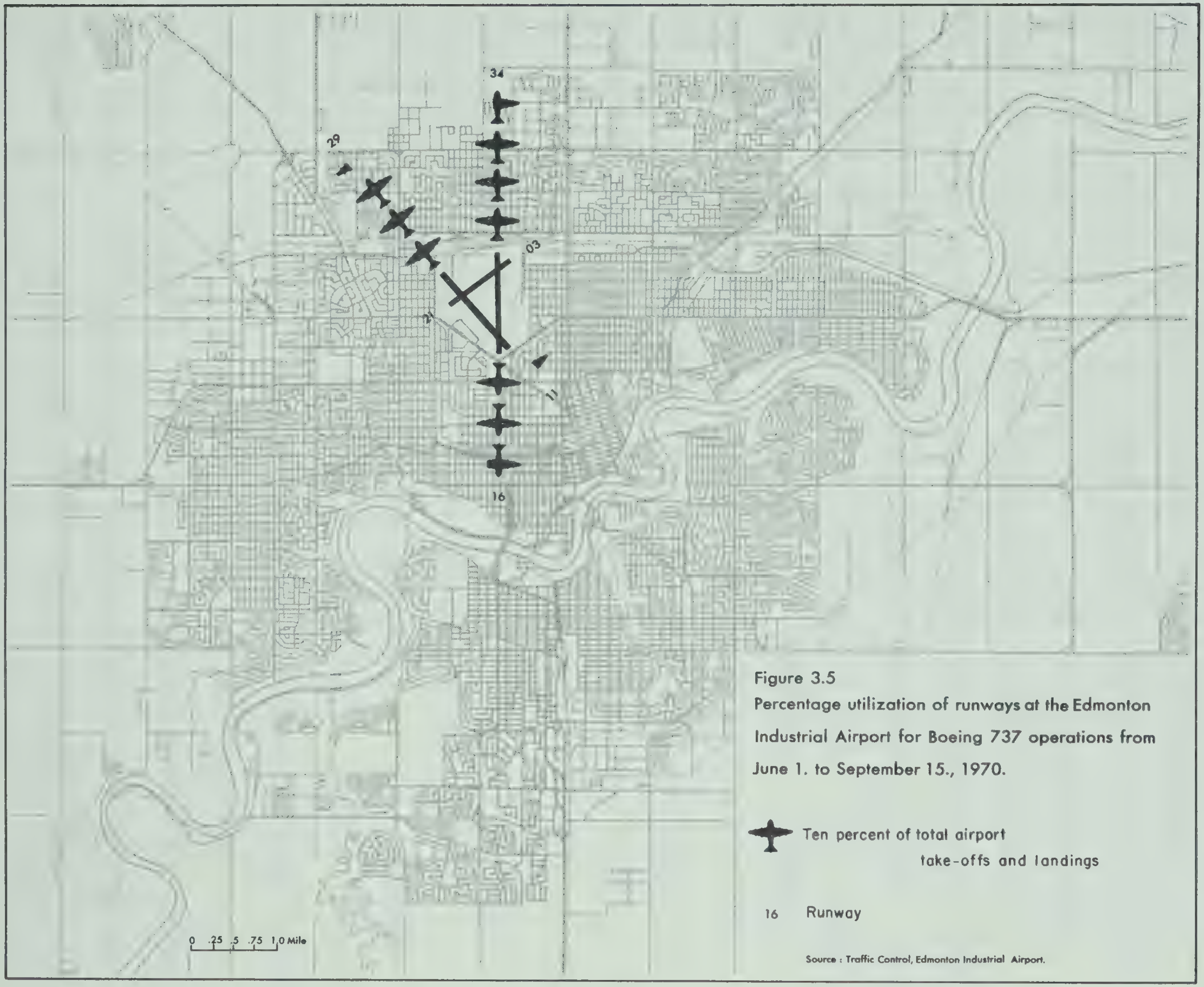


Figure 3.5
Percentage utilization of runways at the Edmonton Industrial Airport for Boeing 737 operations from June 1. to September 15., 1970.

Source : Traffic Control, Edmonton Industrial Airport.

overflights and therefore, aircraft noise than other areas.

The Composite Noise Rating, which consists of certain weightings based on average listener responses to noise, is applied to the PNdB noise contours of an aircraft to account for the frequency and time of aircraft noise exposure. Table 3.1 lists these weightings according to the number of aircraft overflights and the percentage utilization of a particular flight path. In Table 3.2 the number of landings and take-offs for several types of aircraft are tabulated for each runway at the Industrial Airport. The information which was collected for the time period, June 1, 1970 to September 15, 1970, omitted Saturdays and Sundays. Bolt, Beranek and Newman, in their Technical Report (1964), suggest the use of a period of maximum activity. Saturdays and Sundays are shown in Table 3.3 to be periods of minimum Boeing 737 activity at the airport. Also, the absence of these days enables a more meaningful comparison to be made between aircraft noise and motor vehicle noise which was measured only on weekdays because of the large variation in flow and type of vehicle between the weekday and weekend. In contrast to the decrease in scheduled Boeing 737 flights from the airport during the weekend the number of unscheduled small aircraft flights increase. The noise from small aircraft is very limited in extent as compared to the Boeing 737 but has been found to cause serious annoyance of residents living near the airport

TABLE 3.1. OPERATIONAL CORRECTIONS TO APPLY TO PERCEIVED NOISE LEVELS FOR TAKE-OFFS AND LANDINGS

Number of Take-offs or Landings Per Period		Correction
Day (0700-2200)	Night (2200-0700)	
Less than 3*	Less than 2	-10
3 - 9	2 - 5	-5
10 - 30	6 - 15	0
31 - 100	16 - 50	+5
More than 100	More than 50	10
Percent Runway Utilization		Correction
31 - 100		0
10 - 30		-5
3 - 9		-10
Less than 3		-15

* If the average number of operations for an aircraft type is less than one per time period, that aircraft class should not be considered in the analysis.

Source: Bolt, Beranek, and Newman, Inc., Land Use Planning Relating to Aircraft Noise, October, 1964, p. 10.

TABLE 3.2. TAKE-OFFS AND LANDINGS AT EDMONTON INDUSTRIAL AIRPORT

JUNE 1, 1970 TO SEPTEMBER 15, 1970

(Saturdays and Sundays excluded)

Type of Aircraft	Take-off Runways					Landing Runways				
	16	34	29	11	Total	16	34	29	11	Total
737	195	216	224	2	637	155	238	198	38	629
DC6B	33	40	50	0	123	39	54	31	7	131
CV640	42	39	59	0	140	31	54	43	14	142
DC4	7	9	14	0	30	12	10	8	3	33
Total	277	304	347	2	930	237	356	280	62	935

737 - Boeing 737 (Jet)
DC6B - Douglas DC-6B (Piston)
CV640 - Convair Jet Prop
DC4 - Douglas DC-4 (Piston)

Source: Traffic Control, Edmonton Industrial Airport.

TABLE 3.3. WEEKEND OPERATIONS AS A PERCENTAGE OF THE TOTAL OPERATIONS FOR THE TIME PERIOD JUNE 1, 1970 TO SEPTEMBER 15, 1970 AT THE EDMONTON INDUSTRIAL AIRPORT

Type of Aircraft	Take-off Runways					Landing Runways				
	16	34	29	11	Total	16	34	29	11	Total
737	23	10	14	0	16*	24	16	13	14	17
DC6B	30	13	26	0	23	24	18	11	22	19
CV640	33	36	17	0	26	23	18	19	22	20
DC4	63	31	33	0	43	40	38	38	40	39
Total	27**	14	17	0	19	24	17	14	16	17

* - 16% of total Boeing 737 take-offs between June 1 and September 15, 1970 took place during weekends.

** - 27% of total take-offs on Runway 16 between June 1 and September 15, 1970 took place during weekends.

because of its interference with outside leisure activities.

The CNR is calculated for each class of aircraft for landing and take-off and the maximum CNR is used. The CNR for the 737 is the maximum CNR for each runway because of the greater number of operations compared to the other three aircraft classes. In the latter cases, CNRs cannot be calculated because of the rule which states that if the average number of operations is less than one per time period then that aircraft class should be disregarded. The time period used is 77 days and in Table 3.2 it is evident that only Boeing 737 aircraft have an average number of operations in excess of one (1).

Tables 3.4 and 3.5 are worksheets showing the total corrections for each runway and the calculated CNRs. For example, the total correction for take-off from Runway 16 is minus 10 (-10). The 100 CNR for that runway is therefore the 110 PNdB contour which is smaller in area than the 100 PNdB contour. This implies that due to the fewer number of flights as compared to other major airports and the fact that flights take place only during the day, the total aircraft noise environment is perceived as quieter than Figure 3.4 would suggest. Figure 3.6 depicts the 90 to 120 CNRs for the Industrial Airport and represents a much more realistic description of the aircraft noise environment of Edmonton than the strictly physical description as shown in Figure 3.4.

TABLE 3.4. COMPOSITE NOISE RATING CALCULATIONS (TAKE-OFF)

Aircraft Type	Number of Days	Total Ops.	Average Ops.	Runway	% Util.	Corr. No.	Corr. % Util.	Total Corr.	CNR	PNdB Contour
737	77	195	2.53	16	30.61	-5	-5	-10	100	110
737	77	216	2.81	34	33.91	-5	0	-5	100	105
737	77	224	2.91	29	35.16	-5	0	-5	100	105
737	77	2	0.03	11	.32	x	x	x	x	x

Total Ops. - Total number of movements for that aircraft class.
Average Ops. - Average number of movements for that aircraft class.
% Util. - The average percentage utilization for that runway.
Corr. No. - The correction for number of operations (refer Table 3.1.).
Corr. % Util.- The correction for runway utilization (refer Table 3.1.).
Total Corr. - The total operational corrections.
CNR - The CNR to be determined (100 CNR used in above table as an example).
PNdB Contour - The PNdB contour from the appropriate contour set that is to be used to draw the desired CNR.

TABLE 3.5. COMPOSITE NOISE RATING CALCULATIONS (LANDINGS)

Aircraft Type	Number of Days	Total Ops.	Average Ops.	Runway	% Util.	Corr. No.	Corr. % Util.	Total Corr.	CNR	PNdB Contour
737	77	155	2.01	16	24.64	-10	-5	-15	100	115
737	77	238	3.09	34	37.84	-5	0	-5	100	105
737	77	198	2.57	29	31.48	-10	0	-10	100	110
737	77	38	.49	11	6.04	x	x	x	x	x

Total Ops. - Total number of movements for that aircraft class.
Average Ops. - Average number of movements for that aircraft class.
% Util. - The average percentage utilization for that runway.
Corr. No. - The correction for number of operations (refer Table 3.1.).
Corr. % Util. - The correction for runway utilization (refer Table 3.1.).
Total Corr. - The total operational corrections.
CNR - The CNR to be determined (100 CNR used in above table as an example).
PNdB Contour - The PNdB contour from the appropriate contour set that is to be used to draw the desired CNR.

FIGURE 3.6

COMPOSITE NOISE RATINGS
90 TO 120

JUNE TO SEPTEMBER 1970

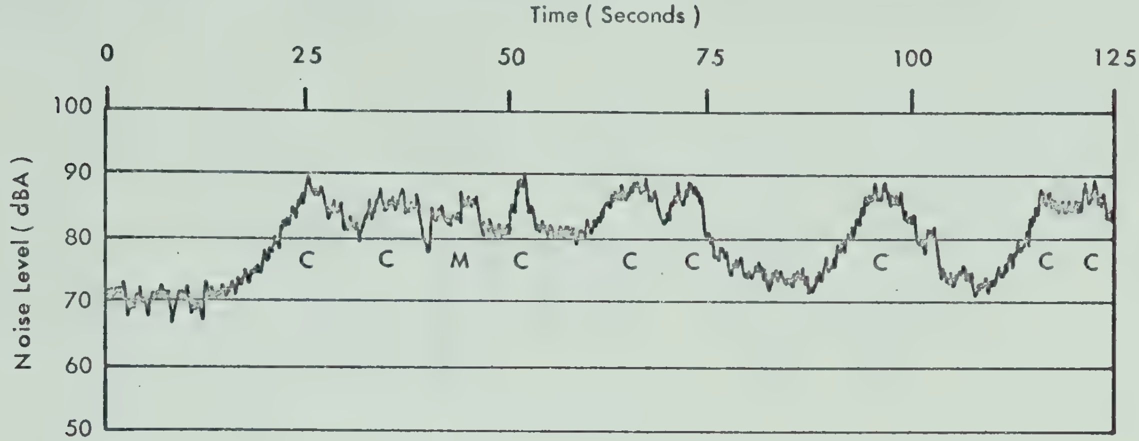
EDMONTON INDUSTRIAL
AIRPORT

3.2. Results of Edmonton Traffic Noise Survey

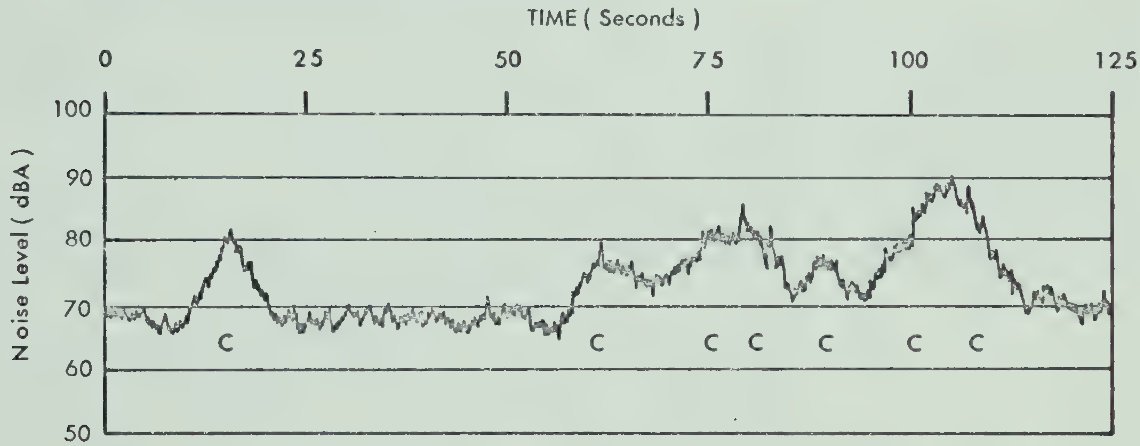
In a total planning approach the costs and benefits of eliminating undesirable features of urban living such as noise, fumes, vibration, and visual intrusion due to a traffic route must be considered along with aircraft noise. In most cases these penalties outweigh the advantages of access and movement and a decision must be made as to the permissible traffic volume and character which will enable the area to maintain desirable living conditions (Buchanan Report, 1964). Recognizing this need, this section presents an examination of traffic noise information collected during the summer of 1970 at 21 locations within Edmonton. A description of these sampling sites and the technique of measurement involved was presented in Chapter Two. Sample noise level time histories for the morning, afternoon, and night at Location 12 are displayed in Figure 3.7. In Figure 3.8 the mode noise level in dBA and the range from minimum to maximum recorded levels for each of the 63 readings are divided into the three time periods and within each time period the sites have been arranged in order of increasing mode size. The differences in the ranges of noise and in the mode levels between the time periods as well as between sites are related to traffic flow; the higher the traffic volume or flow, the more intense is the resulting noise.

The average annual daily traffic flow for 1970 is

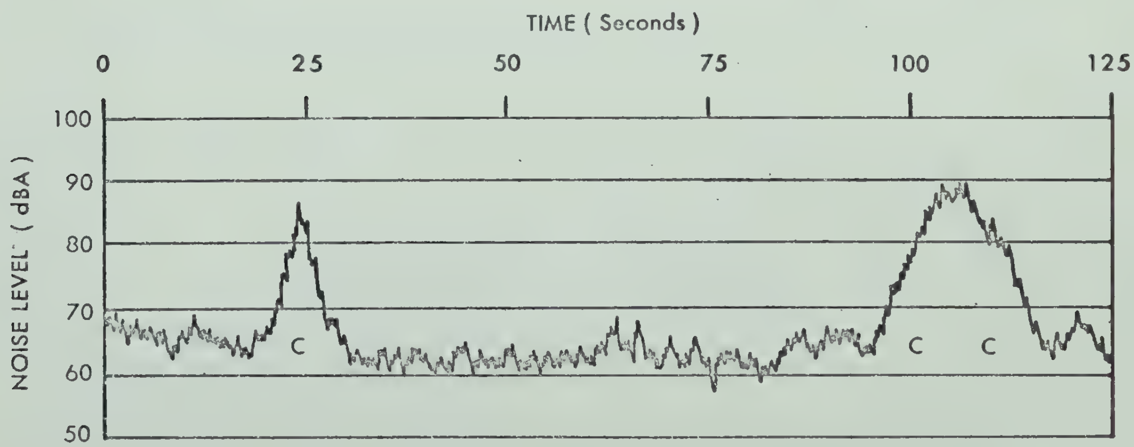
Figure 3.7 Sample noise level time histories for Location 12.



Morning (0800 hours to 1000 hours)



Afternoon (1500 hours to 1700 hours)

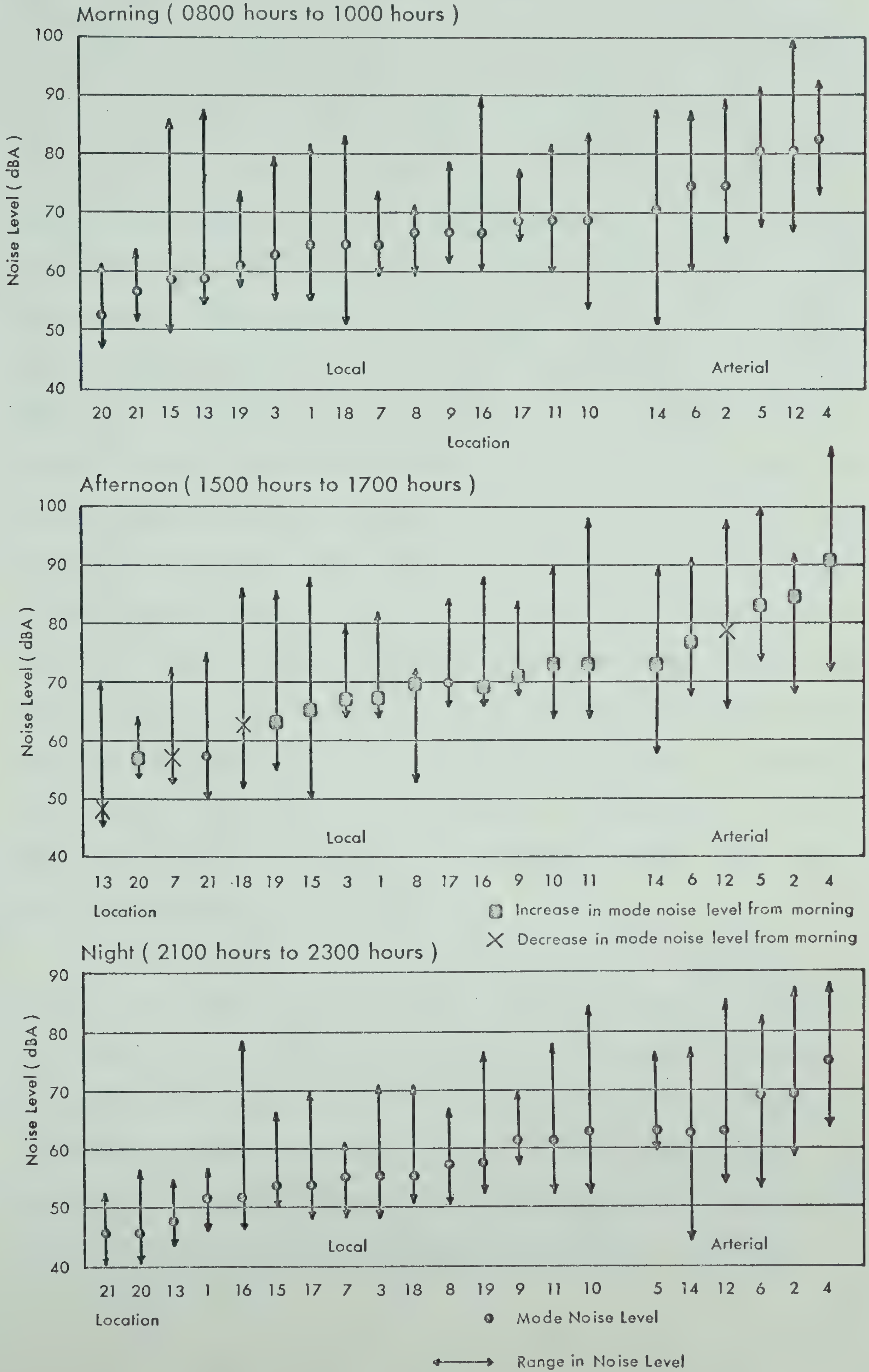


Night (2100 hours to 2300 hours)

C Car

M Motorcycle

Figure 3.8 Mode noise level and range in noise levels for the 21 sampling sites.



represented in Figure 3.9. Sites 2, 4, 5, 6, 12, and 14 (refer Figure 2.11 on page 61) are on arterial routes or what the Edmonton Traffic Engineering Department (1970) classifies as routes primarily for traffic movement and secondarily for access and carrying 10,000 to 30,000 vehicles per day at an uninterrupted flow except at signals and crosswalks. The remaining sites are located along locals and collectors which are used more for access to property than for movement and their daily flow is therefore much lower than the arterial routes. A distinct difference between noise recordings along arterial and local streets is observed in Figure 3.8. During the morning all the arterial route readings exceed 70 dBA while the local readings reach a maximum mode level of 69 dBA. The levels are higher during the afternoon with Site 4, the junction of 104 Avenue and 107 Street, having a mode value of 91 dBA. A similar difference between arterial and local sites exists during the night readings in which an arterial site's mode noise level always exceeds 60 dBA.

Measurements of freely-flowing traffic by Bolt, Beranek and Newman (1967) reveal that for each doubling of distance from a traffic route, which represents a 'quasi-steady-state' source of noise distributed along a line, a decrease in sound pressure level of three decibels is achieved. When buildings are placed between the source and the listener a maximum shielding decrease of 15 dB is

FIGURE 3.9

1970 - TRAFFIC FLOW MAP

THE CITY OF EDMONTON
ENGINEERING DEPARTMENT
TRAFFIC BRANCH

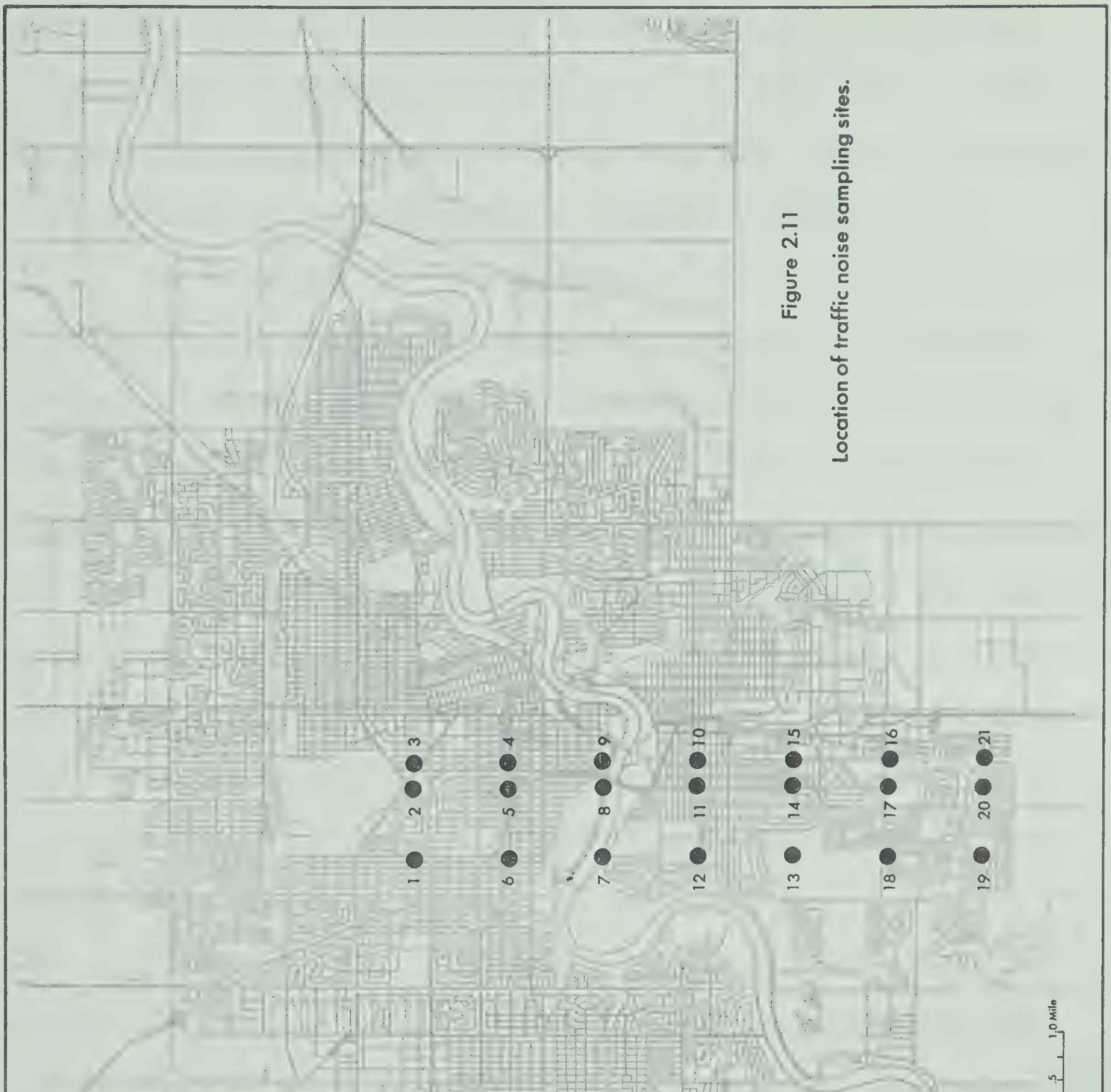


Figure 2.11

Location of traffic noise sampling sites.

attainable (Wiener et al., 1965). The relatively high afternoon noise levels at local sites 10 and 11 may be explained by their proximity to Whyte Avenue, an arterial route carrying 27,000 vehicles each day (Edmonton Traffic Engineering Department, 1970), and by the absence of buildings between the local sites and Whyte Avenue.

In addition to 'quasi-steady-state' traffic noise, arising from the flow of passing automobiles, 'discrete moving noise sources' are identified by Bolt, Beranek and Newman (1967). The sources, usually trucks, superimpose a peak in sound pressure level upon the 'background' of automobile noise and field measurements indicate a 6 dB decrease with each doubling of the distance from the source. Measurements of discrete sources were not made simultaneously with the quasi-steady traffic noise measurements made in this study and therefore, validation of the decrease with distance factor of 6 dB was not achieved.

Figure 3.10 is a traffic noise map of Edmonton in which the traffic noise environments of the city streets are classified simply as 'noisy' and 'quiet'. The terms 'noisy' and 'quiet' are used in preference to a range in dBA values because it would be presumptuous on the part of the author to designate such definite values on the basis of only 63 readings. The 'noisy' streets are all those which carried an annual daily average traffic flow in excess of 10,000 vehicles for 1970. Any streets with a flow of

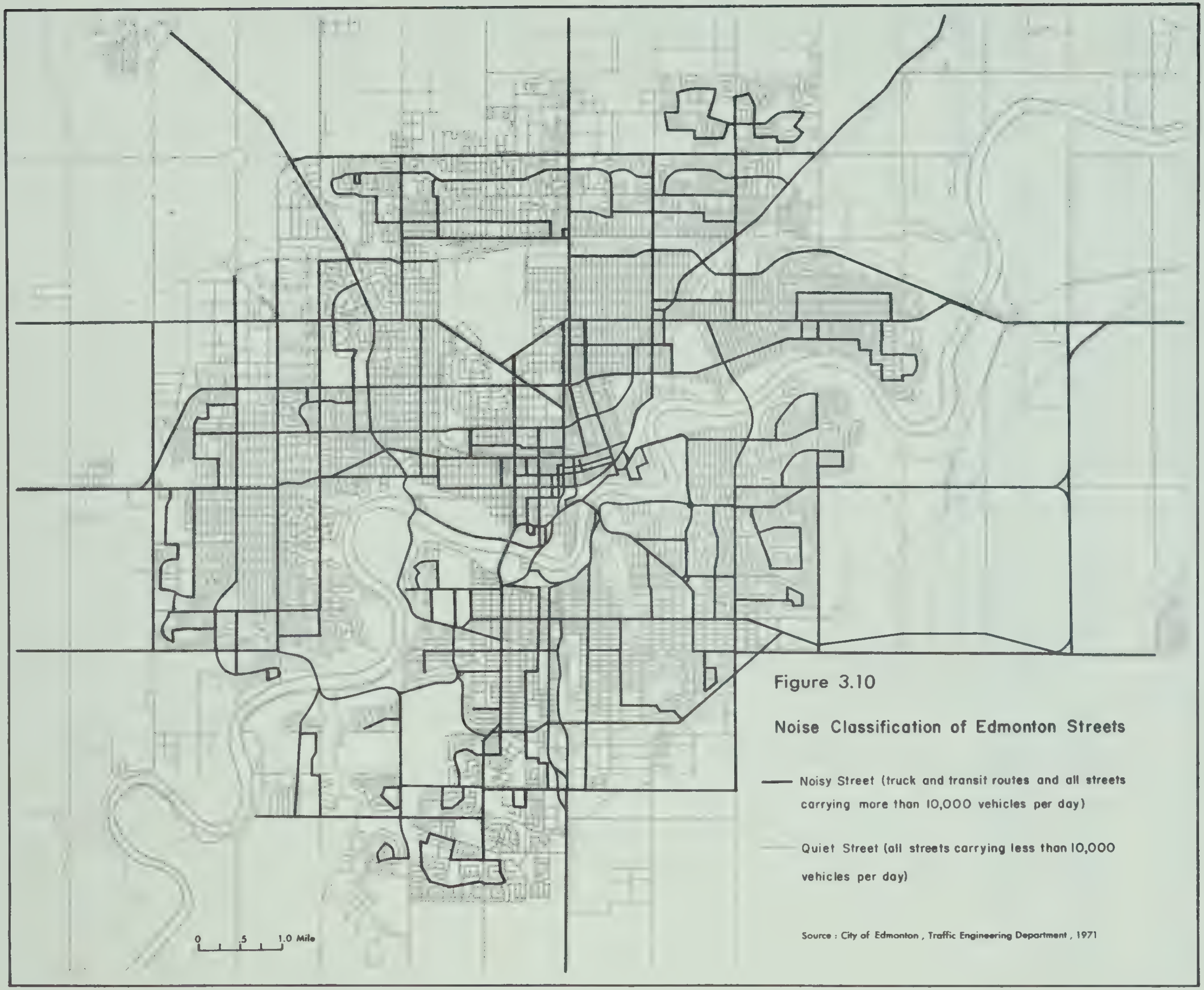


Figure 3.10

Noise Classification of Edmonton Streets

— Noisy Street (truck and transit routes and all streets carrying more than 10,000 vehicles per day)

— Quiet Street (all streets carrying less than 10,000 vehicles per day)

Source : City of Edmonton , Traffic Engineering Department , 1971

less than 10,000 vehicles but classified as truck or public transit routes are also included as 'noisy' streets because of the effect of these 'discrete moving noise sources' on the background noise.

The applicability of the Composite Noise Rating and the above traffic noise findings to urban planning and development is examined in Chapter Six.

CHAPTER FOUR

PERCEPTION OF NOISE

Theories on the manner in which an individual perceives and reacts to the physical world range from determinism, which recognizes the environment as all-powerful, allowing man no choice in his reactions, to cognitive behaviorism which suggests that "a person reacts to his milieu as he perceives and interprets it in the light of his previous experience" (Saarinen, 1966, p. 26). In this study the author has accepted the latter theory in the belief that social history shows that man is constantly being faced with situations such as drought and flood and perceives and reacts according to his past experiences and his personal preferences, attitudes and values as determined by his culture.

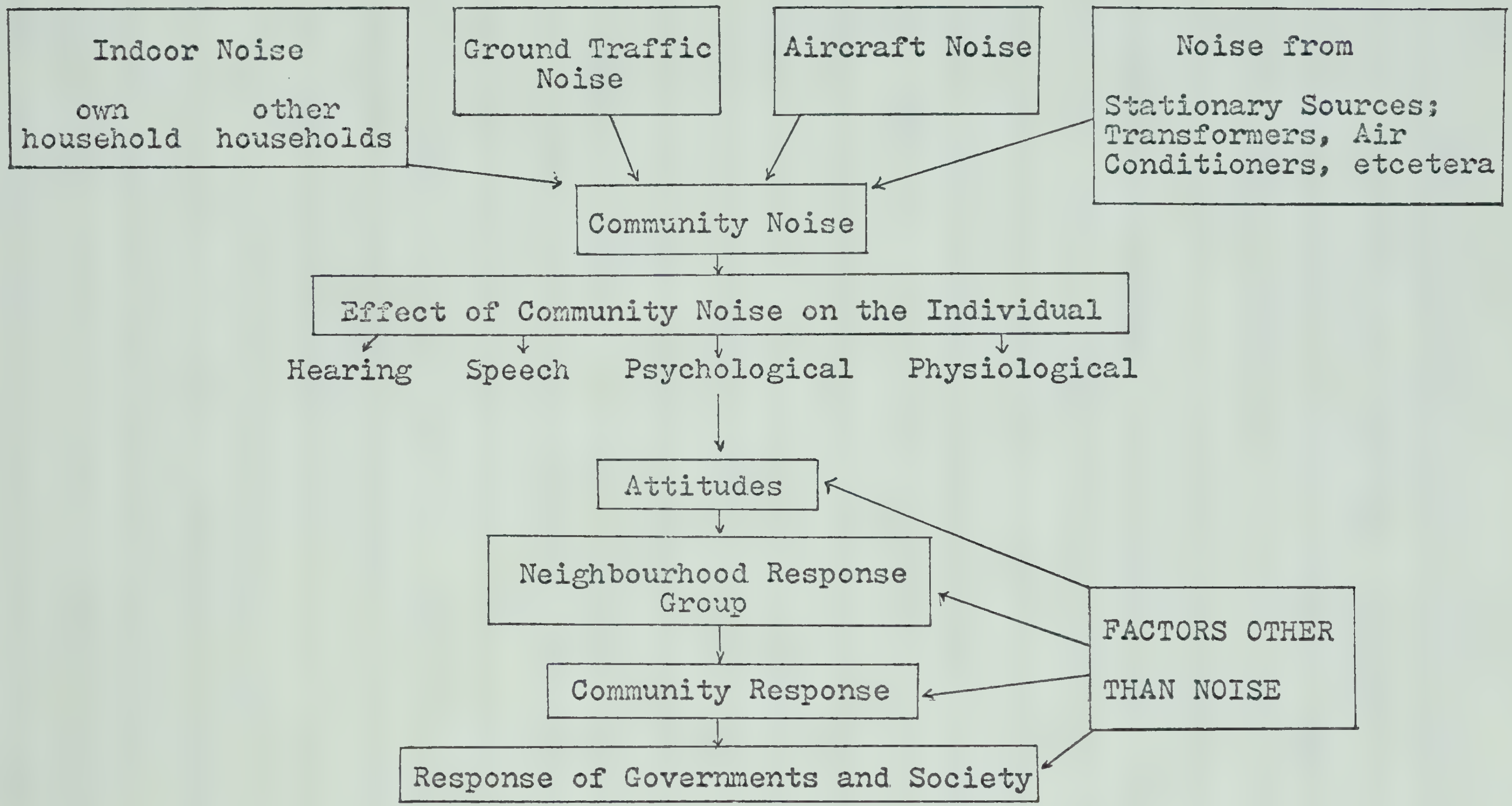
Through this perception process the individual arrives at an impression of the real or objective world. This has significant planning implications because it tells the planner what the goals and desires of the individual are and hence what changes in the urban environment are needed. Dust and noise were more acceptable to the urban dwellers of the late nineteenth century than today's city residents because, in terms of the social conscience of

that day, such features of the physical environment conveyed a feeling of growth and economic prosperity - a desired goal. Recently man's view or perception of a desirable or ideal environment reflects a change in his attitudes to and values within his society; no longer is dust and noise identified with economic well-being. Comfortable housing, greater mobility, and more aesthetically pleasing landscapes, among other perceived needs, have all placed stress on urban planning. This stress will not disappear until the social and cultural nature as well as the economic nature of these problems are identified and appreciated. Perception studies are the tools best equipped for defining social needs by identifying individual needs and goals.

Noise is an aspect of the urban environment which has increasingly become undesirable to the city dweller. This study attempts to identify why and in what ways noise is unwanted and in so doing, describes the desirable noise environment. Knowing what noises disturb and the conditions under which they disturb will assist in the design and initiation of changes in the noise environment which will lead to an improvement in man's condition.

Figure 4.1 shows how von Gierke (1969) views the relationship between the individual and his noise environment. The previous chapter described two major producers of community noise, traffic and aircraft. However, one must be aware that a city resident will be exposed to many other

Figure 4.1 THE COMMUNITY NOISE PROBLEM, from von Gierke, 1969.



sources of noise ranging from modern domestic appliances such as the garburator and dishwasher to industrial sources such as transformers and riveting machines. The ability to measure the physical parameters of noise is a well-established art as witnessed by the sound level meter and other sound recording instruments (see Appendix II). The measurement of the effect of these noises on the individual, however, is not such a well-defined science and it is for this reason that composite measures such as the CNR are advisedly used only for guideline purposes and that before decisions are made concerning a particular noise producer an intensive study of the community's reactions is suggested.

The effect of noise on man's hearing acuity and communication or speech ability has been studied. (Figure 2.2 defines the distance and voice level requirements needed to ensure speech intelligibility for SIL values.) However, the effect of noise on the psychological functions of the body have not been definitely identified and until all these effects have been determined, an assessment of the total individual response to noise cannot be made. Until this is accomplished the individual's attitudes concerning noise will not be fully understood. For example, it has been suggested that noise will contribute to such diverse physical disorders as heart disease, hypertension, paranoia, impaired vision, and even foetal disorders (Mecklin, 1969). Until the types and intensities of noise

causing these and other physiological and psychological disorders are established, our knowledge of the influence of noise on man and hence, our knowledge of his perception of it, will remain incomplete.

Factors other than noise will influence the final attitude toward the noise environment. If the listener believes that the noise is a necessary by-product of a source which produces a useful commodity or service then he may be tolerant of the noise. If he feels that those responsible for the noise are aware of the problem and are working towards its elimination then again, the listener may be tolerant of the noise. (It is important to note that tolerance is not a permanent feeling but that it varies in degrees according to the particular situation faced by the listener.) However, if he feels that these same people are irresponsible and unconcerned about his welfare and are doing nothing to minimize the noise then he may feel annoyed and may react accordingly. Borsky (1969) proposes this feeling of being exploited or 'used' as a cause of contemporary urban discontent by minority groups. The author found that around the Edmonton Industrial Airport several individuals felt this sense of not being listened to and felt that the responsible authorities were not sympathetic to their plight. It is significant that the same residents showed their annoyance by signing an anti-noise petition and in one instance, presented a brief to the city fathers.

The types of activities interfered with by noise will also determine how that noise will be viewed. Thiessen (1969a, p. 7) found that a 70 dBA noise will probably awaken a sleeping individual but that at a level of 50 dBA there is a 50 per cent probability that there will be no reaction. A 70 dBA noise level in a living room, however, is below the average Speech Interference Level or level at which speech communication begins to be impaired. An awakened person will react quite differently to a particular noise than a person conversing or watching television.

A person may believe that noise affects his health and will therefore be more aware of it and more likely to become annoyed. On the other extreme, Webster and Lepor (1968) have found that individuals may adapt psychologically to high noise levels, as high as 90 dBA, with no appreciable decline in their ability to accomplish a task. This factor when examined in relation to personal mobility and length of residence has major significance when investigating community perception of noise. In a community survey, therefore, questions must be asked which will identify which activities are interfered with by noise, the sources of noise, and to what extent these activities are interfered with or interrupted. By identifying the extent to which a noise interferes with an activity, it may be possible to establish noise levels beyond which an individual may complain about the noise. Whether or not the annoyed person

will actually complain depends on several factors unrelated to the noise level (Borsky, 1969).

A person involved with community organizations, which are convenient organs for voicing opinions, will have greater opportunity to complain about a community problem than a non-member. The ability of a person to articulate his ideas and influence others will determine how vocal he will be about neighbourhood problems. A faith in the system or a belief that a wrong will be righted will strongly influence whether a person, afflicted by noise, will complain to the authorities or simply remain anonymous. A knowledge or awareness of existing laws and regulations may also be a major factor. The existence of other more pressing neighbourhood problems such as a crime or racial problem may overshadow the significance of a noise problem and make it appear trivial in the total living environment of that area.

4.1. Discussion of Edmonton Noise Questionnaire Survey

The above discussion of the factors influencing the manner in which an individual will perceive and react to community noise forms a basis for the questionnaire survey which was conducted in Edmonton during the summer of 1970. One resident was interviewed in the vicinity of each of the 21 traffic noise sampling sites. This case-study approach was employed instead of a statistically-significant sample

approach because of the desire to develop an in-depth appreciation of the factors influencing noise perception. Having established these factors, an extensive survey would then be necessary in order to define the areal extent of the problem. This could then be profitably applied to any planning developments by anticipating community reaction to the introduction of a potentially noisy activity such as a drive-in restaurant or change in operation of an existing activity such as extended operating hours at an airport.

The questionnaire (Appendix IV) begins with questions pertaining to age, occupation, and education. The responses to each question are given in Table 4.1. None of these factors appear to be related to the manner in which a person perceives his neighbourhood problems or expresses himself. A young man may be just as apathetic or intensely annoyed about a noise problem as an elderly lady. However, it was found that elderly people who had lived at the same residence for many years considered community noise no problem. This may be attributed to loss of hearing acuity due to old age but the author did not measure this factor. Almost all long-term residents noted an increase in the community noise level since they first settled there. A standard statement by these people was "You have to live with a certain amount of noise" or "You get used to it". Perhaps these long-term residents are rationalizing the problem away, a valid suggestion, because all of these people also

mentioned the problems involved in moving to quieter surroundings - "I've lived here 21 years and I'm retired, how can I move?". When asked why a person had moved from his last residence, no one offered noise as a major factor. Need for a job or a desire to be close to a school rated as main reasons for a change in residence. This suggests that noise is not a dominant problem in Edmonton although a case of 'falling expectations' for one's neighbourhood would tend to camouflage the noise problem.

Questions about proximity to work and shopping facilities seemed to relate closely to a person's feelings about his neighbourhood. If a person felt isolated from shopping facilities or felt he had to travel unnecessarily far to work, he usually felt dissatisfied with his neighbourhood, noise included. In every case these people felt that the city had dealt insufficiently with neighbourhood problems. Such problems ranged from taxes to barking dogs to roaring motorcycles. Significantly, people satisfied with their neighbourhood felt that pressing problems such as drugs, lack of low cost housing and lack of communication between the public and the elected officials did not apply to their neighbourhood. Those residents annoyed with noise and far from their work place seemed to identify their neighbourhood with all these urban problems.

Aircraft noise was never accused of waking the interviewed person but in several cases, traffic noise was

extremely annoying because it woke children. All these residents were located along arterial routes identified with high rates of flow as well as high truck activity. Only in Noise Sensitivity Zones I and II (see Chapter Six) did aircraft interrupt conversation and cause windows to vibrate. Television interference caused by aircraft had been experienced in all sampling locations and although this interference is not strictly noise interference, residents associated this disruption with noise. Traffic and aircraft noise were cited as the major noise problems but other disturbing noises included lawnmowers and children playing in the neighbourhood. When asked why or in which way noises were disturbing, residents stated that the main reason was that the noises were unnecessary, and in some instances, such as motorcycle noise, simply a case of poor manners and a sign of lack of consideration for fellow neighbours.

Most of the people interviewed stated that noise became most annoying during the evening when they were relaxing before the television. Near the airport, early morning flights (before 0800 hours) caused annoyance. In areas near railway lines the noise from shunting trains after midnight was cited as a major nuisance.

When asked about the number of overflights each day and the duration of each overflight a vast range of answers was obtained. Persons unaffected or unconcerned about

aircraft noise clearly guessed about both the number and duration of overflights while those residents annoyed with aircraft noise were extremely close in their estimates. Likewise, those residents annoyed with aircraft noise appeared to be more aware of the existence of authorities responsible for the control of aircraft noise.

The area of most awareness of aircraft noise was found around Location 3. This area is composed of single dwelling homes built since World War II, the majority of people having resided in the neighbourhood for more than ten years. Several of the residents stated that they had built homes in this area on the information that the airport would be removed and a light industrial park established. Which particular authority gave this promise was not ascertainable.

During 1969 the neighbourhood organized and an anti-noise petition was prepared and distributed throughout the city. Mr. Walter Stanley presented a brief to City Council on November 10, 1969 on behalf of his fellow residents. This brief called for the closure of the Edmonton Industrial Airport for three main reasons. The first reason mentioned was the danger of an air-crash. The residents had experienced several crashes of light aircraft and felt that it was inevitable that a large transport or passenger aircraft would fail to land or take-off safely with consequent disaster in their area. The second reason for instigating closure of the airport was noise, and the third reason was the

fact that since "this airport is not capable of handling any more traffic without excessive expansion... where can the Industrial Airport expand in its present location?" (Mr. Walter Stanley, pers. comm., 1970). After suggesting alternate sites for the airport, the brief concluded,

> So let us, as thoughtful citizens, with a view to the future and to the best interest of Edmonton, start now, take necessary action and mediate with all concerned so that, before it is too late, and before we spend more money, and solve this problem so that in the future it can be said, 'We looked ahead and proved that we could act with determination, and we made this a better City for those who came after'.
> (Mr. Walter Stanley, pers. comm., 1970).

The presence of this politically active neighbourhood seems to validate all Borsky's theories on the influence of 'outside' factors on the perception of noise. All the residents stated that aircraft noise caused interruption of conversation and that sleep was sometimes 'impossible'. Several people had been advised by their family physicians to move from the area. This suggestion, in turn, caused intense annoyance with the airport because these people felt that they had a right to a quiet environment. The fact that the airport had not been closed represented, in their opinion, a breach of promise. The feeling that 'vested interests' had taken advantage of them appeared to be the major complaint and aircraft noise and the danger of a crash seemed to be additional arguments against the airport operation.

Several people in this area, which is adjacent to

the Royal Alexandra Hospital, told of patients on the top floor of the hospital requesting to be moved to a lower floor because of noise from aircraft landing and taking-off. The author recorded the outside noise level on the roof of the hospital and found that maximum levels exceeded 115 dBA. However, when the noise level was recorded within the hospital, on the top floor, aircraft noise was found to be masked by noise from the air conditioning system and the existence of double-glazed windows, in conjunction with the air conditioning, served to effectively insulate the ward from outside noise.

Nurses on wards 61, 62, 63, and 64 were interviewed about whether or not they felt that the presence of an airport close to the hospital represented a hazard to the well-being of the patients. Several nurses stated that an aircraft overflight caused vibration of some windows but that these occurred only three or four times during the day-time shift and that it did not make the patients appear uncomfortable or adversely affect the hospital's working conditions. Several nurses were annoyed with aircraft noise while outside the hospital. In every case, these persons lived near the hospital. In particular, those nurses living in the Royal Alexandra Nurses' Residence stated that aircraft noise was a major distraction. Unlike the top floor of the Active Treatment Building, the residence does not have a closed air conditioning system and windows are

open during the summer.

The universal complaint of the nurses about the airport, like the homeowners north of the hospital, was that the low-flying aircraft represented a danger to life and property. While some nurses felt that the airport should be relocated, others felt that if other runways were used, eliminating flights over the hospital, then the airport could be maintained at its present site. Significantly, there has never been an official complaint to the hospital administration on behalf of the nursing staff concerning aircraft noise.

The statement by homeowners that patients at the Royal Alexandra Hospital are made uncomfortable and nervous because of aircraft noise therefore appears to be an unfounded rumour.

Location 3 is classified as Noise Sensitivity Zone III which is an area not recommended for residential buildings. The complaints voiced by these homeowners certainly verify the correctness of such a classification. Whether or not the homeowners have valid arguments for the closure of the airport, it is apparent that the two activities, private residence and an airport, are not compatible. A decision must be made so that Edmonton may indeed become 'a better city for those who come after'.

TABLE 4.1. RESPONSES TO QUESTIONNAIRE
(21 INTERVIEWS)

PART I

1. Address (see Figure 2.11)

2. Age

	Number	Percentage
under 20	0	0
20 - 30 years	5	24
30 - 40 years	4	19
40 - 50 years	6	28
50 - 60 years	1	5
over 60	5	24

3. Occupation

	Number	Percentage
Professional	5	24
Tradesman	11	52
Homemaker	2	10
Retired	3	14

4. Education

	Number	Percentage
Primary	6	28
Secondary	9	44
Post-secondary	6	28

5. Marital Status

	Number	Percentage
Married	16	76
Single	5	24

PART II

1. How long have you lived at your present address?

	Number	Percentage
Less than 5 years	6	28
5 - 10 years	5	24
10 - 15 years	2	10
More than 15 years	8	38

2. Where did you live before this?

	Number	Percentage
Farm	3	14
Rural community	7	34
Urban	11	52

TABLE 4.1. (CONTINUED)

3. Why did you move?

Employment reasons	11	52
Desire to buy own house	9	43
Proximity to school	9	43
Cheaper taxes and rent	4	19
Expropriation of former property	1	5

4. Do you have far to travel to work?

Yes	3	14
No	18	86

5. Are you far from shopping facilities?

Yes	2	10
No	19	90

6. In your opinion, what are the most pressing problems in Edmonton today?

Air and water pollution	8	38
Traffic congestion	8	38
Lack of low cost housing	7	34
Traffic noise	7	34
Drugs	6	28
Lack of recreational facilities	6	28
Aircraft noise	5	24
Need for re-evaluation of education priorities	3	14
Uncontrolled urban growth	3	14
Lack of communication between government and people	3	14

7. Do you feel that the city has dealt sufficiently with problems that have arisen in your neighbourhood?

Yes	7	34
No	14	66

8. What are the main problems in your neighbourhood?

Taxes	9	43
Motorcycle and truck noise	7	34
Dogs and cats	6	28
Traffic (safety for children)	5	24
Aircraft noise	4	19
Train noise	3	14
Children playing	3	14
Lack of recreational facilities	3	14
Lawnmower noise	2	10

TABLE 4.1. (CONTINUED)

9. Has the noise level in your neighbourhood increased, decreased, or remained the same since you moved here?

Increased	18	86
Remained the same	3	14
Decreased	0	0

10. Do you feel that there is too much or too little fuss made about community noise in the news media nowadays?

Too little	14	66
No opinion	4	20
Too much	3	14

11. Does noise ever:

Interrupt a radio or T.V. program	15	72
Wake your children	9	43
Interrupt conversation	9	43
Make your house vibrate	9	43
Wake you	3	14

12. What particular noises disturb you?

Motorcycle noise	11	52
Aircraft noise	9	43
Traffic noise	9	43
Dogs barking	7	34
Truck noise	5	24
Children playing	5	24
Lawnmowers	5	24
Construction noise	4	19
Train noise	4	19
Neighbourhood parties	1	5

13. Why, or in what way, are these noises disturbing?

Feel that noise is unnecessary	9	43
Interferes with T.V.	9	43
Feel that noise-maker is inconsiderate	6	28
Disturbed during sleeping hours	5	24
Fear of car-child accident	3	14

14. During which time of the day does noise most disturb you?

Early evening (before 10:00 p.m.)	12	58
Night (after 10:00 p.m.)	7	34
Morning	5	24
Afternoon	3	14

TABLE 4.1. (CONTINUED)

15. Does noise most disturb you when you are working or relaxing?

Relaxing	18	86
Working	5	24

16. Could you sum up your opinion by saying you find noise in general:

A little disturbing	15	72
Very disturbing	3	14
Not at all disturbing	3	14

17. Have you ever moved your residence because of noise specifically?

Yes	0	0
No	21	100

18. Do aircraft ever:

Make your T.V. flicker?

Yes	14	66
No	7	34

Make your house vibrate?

Yes	4	19
No	17	81

19. How many aircraft fly over your house each day?

Less than 5	5	24
6 - 10	7	34
11 - 15	4	19
16 - 20	2	10
More than 20	3	14

20. How long does an aircraft flyover last?

Less than 30 seconds	7	34
30 - 60 seconds	8	38
More than 60 seconds	6	28

21. Do you have double-glazed or storm windows on your residence?

Yes (permanently installed)	15	72
Yes (removed during summer)	6	28
No	0	0

TABLE 4.1. (CONTINUED)

22. Which of the following is noisiest?

Jet taking-off	13	62
Jet landing	8	38
Propeller aircraft taking-off	0	0
Propeller aircraft landing	0	0

23. To what extent is the Industrial Airport important to the citizen of Edmonton?

Important		
It has a convenient location	3	14
It is a revenue source for the city	2	10
It is important to Edmonton's development	1	5
Not Important		
It is a safety risk	7	34
It is a noise nuisance	5	24
International Airport should be more fully utilized	4	19
It is no longer convenient to the traveller	4	19
No Opinion	1	5

24. Who owns and operates the Industrial Airport?

City of Edmonton	14	66
Federal Government	2	10
Do not know	5	24

25. Is noise a necessary by-product of our standard of living?

Yes	4	19
No	17	81

26. Have you ever complained to the authorities or anyone else about neighbourhood problems?

Yes	9	42
No	12	58

27. In particular, have you ever complained about noise?

Yes	8	38
No	13	62

TABLE 4.1. (CONTINUED)

28. What government agency is involved in noise control?

City Council	7	34
Police Department	5	24
Public Health Department	3	14
Provincial Legislature	2	10
City Engineering Department	1	5
Federal Department of Transport	1	5
Do not know	5	24

29. Do you feel that industry is aware of the noise problem?

Yes	18	86
No	3	14

Are they doing anything about it?

Yes	7	34
No	14	66

30. Do you feel that complaints by the private citizen 'do any good'?

Yes (if organized)	9	42
No	12	58

CHAPTER FIVE

URBAN AND INDUSTRIAL NOISE LEGISLATION

5.1. Present Noise Legislation

In 1930 Justice Luxmore made the following judgement concerning noise in the case of Vanderpont v. Mayfair Hotel Company Limited (National Research Council of Canada, 1968, p. 1):

> Every person is entitled as against his neighbour to the comfortable and healthful enjoyment of the premises occupied by him and ... it is necessary to determine whether the act complained of is an inconvenience materially interfering with the ordinary physical comfort of human existence not merely according to elegant or dainty modes and habits of living but according to plain and sober and simple notions obtaining among English people.

Since the above judgement was made in 1930 public pressure for the legal control and abatement of noise and compensation for damages due to noise has increased. As well, the courts have become aware of the fact that decisions based on such verbal judgements are no longer adequate because of the increased ability of science and technology to identify and measure man's psychological and physiological reactions to and perceptions of various types and levels of noise.

Noise has detrimental effects on the psychology as

well as the physiology of an individual. Industrial hygienists have developed sophisticated measures of the levels and types of noise which affect the worker and much legislation has been instituted which incorporates these findings. This knowledge is also embodied in contemporary legislation dealing with urban noise or noise such as traffic noise which afflicts the city 'resident' as opposed to industrial noise which is exposed to the 'worker'. Decibel limits on traffic noise are proving to be more adequate in controlling the urban noise environment than previous vague verbal limits.

In the following discussion, Canadian and American noise legislation, both based on English common law, is examined within these two major categories; Industrial Noise Legislation and Urban Noise Legislation. In both of these broad categories noise control laws and regulations "involve balancing the rights and remedies of the individual against the rights and remedies of society" (Kaufman, 1969, p. 327).

5.1.1. Urban Noise Legislation

The public nuisance statute and the common law have, historically, been the codes used to achieve action to restrain or seek damages from an offending noise source (Fredrikson, 1969, p. 1). The zoning bylaw, by restricting an area to a certain use such as residential, commercial,

or industrial, has indirectly attempted to control the production of noise. The recent use by several Canadian and American cities of decibel limits in legislation as an aid in the control of traffic noise and the design of more reasonable land use zoning ordinances has been a significant contribution to the control and abatement of urban noise.

5.1.1.1. Common Law Nuisance Action

A common law nuisance may be defined as "one which ... violates the principles which the common law has established for the protection of the public and of individuals in the exercise and enjoyment of their rights" (Cooke, et al., 1970, p. CL-1).

A nuisance may be classified as either a public or as a private nuisance. "Any act or omission which inflicts damage or injury upon the public at large or a considerable portion of it or materially affects their reasonable comfort or convenience of life" (Cooke, et al., 1970, p. CL-1) is a public or common nuisance. If physical damage or the endangering of lives can be proven, then such an act may be ruled as a crime under Section 165 (2) of the Criminal Code.

A private nuisance is defined as the "act of wrongfully causing or allowing the escape of deleterious 'things' into another person's land - for example, water, smoke, smell, fumes, gas, noise, heat, vibrations, electricity, disease-germs, animals and vegetation" (Cooke, et al., 1970, p. CL-2). Unlike the public nuisance, a private nuisance

only involves one person or a specific group of persons and represents a civil rather than a criminal action.

The problems of using the common law in obtaining remedies for urban noise problems are aptly explained by the Columbia Journal of Law and Social Problems (1968, p. 108).

> Although decisions in nuisance cases involve a balancing of numerous factors, such as the gravity of the harm, the social value of the defendant's purpose, and the practical possibility of avoiding the harm, such suits are also not an efficacious remedy for urban noise problems. Private plaintiffs cannot be relied upon to bring suits against all creators of offensive noise, and often such litigants cannot afford the heavy expense of proving that a remedy is warranted. Offensive city noise, for instance, is often a conglomeration of mixed sounds from unidentified sources, and it is therefore difficult, if not impossible, to prove that a particular defendant is responsible for a particular noise and ought to be restrained from producing it. Further, judges may be reluctant to restrain noises unavoidably created by businesses, since the restraint might force the business to close, causing unemployment. Most importantly, the private nuisance remedy is available only when the plaintiff's enjoyment of <u>his own property is impaired</u>. Thus, neither the employee working in a noisy shop nor the commuter submerged in the echoing caverns of the subway may obtain relief through the use of the private nuisance suit.

5.1.1.2. <u>The Public Nuisance Bylaw</u>

Statutory law supercedes common law and forms the basis for bylaws or ordinances. Such legislation can be imperative or permissive depending upon interpretation by the courts. Imperative legislation refers to a statute allowing or directing a certain activity but without any provisions which would allow a claim of nuisance to be made. Legislation which does not direct a mandatory activity but

in which an activity may be 'reasonably implied' is permissive. The following is Viscount Dunedin's judgement which establishes the basic principles of permissive statutory authority as a defense to an action of nuisance.

> When Parliament has authorized a certain thing to be done in a certain place, there can be no cause for action for nuisance caused by the making or doing of that thing, if the nuisance is the inevitable result of the making or doing so authorized. The onus of proving that the result is inevitable is on those who wish to escape liability for nuisance, but the criterion of inevitability is not what is theoretically possible but what is possible according to the state of scientific knowledge at the time, having also in view a certain common sense appreciation, which cannot be rigidly defined, of practical feasibility in view of situation and expense.
>
> (Cooke, et al., 1970, p. CL-7)

In Canada municipal bylaws are established under the authority of a provincial statute. In the United States bylaws are referred to as ordinances and are authorized by state statutes. Contravention of a bylaw may not be dealt with by arrest but rather with summons.

In 1963 New York instituted an ordinance to deal specifically with noise as a public nuisance. Problems of definition may be found in this law which prohibits "the creation of any unreasonably loud, disturbing, and unnecessary noise, and noise of such a character, intensity, and duration as to be detrimental to the life or health of any individual" (New York, New York, Administrative Code 43-5.0 (a), 1963). Fredrikson (1969) maintains that since it must be shown that public welfare is menaced by a particular noise, that such public nuisance ordinances will not deter

the future production of urban noise.

Enforcement of the ordinance is the responsibility of the police and the New York Police Department Rules and Procedures 3/94.0 (1956) directs officers to "familiarize themselves with all provisions ... relating to unnecessary noise .... They are also responsible that members of the force under their command exercise reason and discretion in the suppression of unnecessary noise and common sense in determining what noise is purely unnecessary" (Columbia Journal of Law and Social Problems, 1968, p. 110).

Edmonton Bylaw No. 23, 1925, concerning the prevention of noise, also reflects a lack of definition and means of enforcement. Section 3 of the bylaw reads, "No person shall permit or allow any <u>unusual</u> or <u>unnecessary</u> noise or noise likely to disturb persons in the neighbourhood to be made upon any premises occupied by him or under his control within the City of Edmonton". The inability to enforce such vague laws is revealed by the ever-increasing ambient noise levels in today's cities.

During 1969 a panel of engineers and public health officials was established in Edmonton to examine the noise problem of that city and make recommendations to city council regarding noise abatement and control. The panel's objective was to produce a decibel bylaw which would be, potentially, a more useful legal tool to deal with modern urban noise production than the 1925 bylaw.

Under the authority of the Municipal Government Act, Section 157 (1)(g), which allows the city council to pass a bylaw "for the purpose of prohibiting, eliminating or abating noise", Bylaw No. 3256 was drafted and enacted on January 1, 1971. The intent of this bylaw is to "prevent a deterioration of the noise environment in this City and to adopt as the acceptable noise level a reading in dBA units according to a sound level meter" (Edmonton Bylaw No. 3256, 1971, p. 1).

This bylaw is significant noise abatement legislation because it defines the physical limits of allowable noise production. In cases involving measurement problems such as noisy neighbourhood parties a public nuisance bylaw still allows the police to interpret 'unnecessary' noise as a means of maintaining the private citizen's enjoyment of his neighbourhood. A detailed examination of the applicability of this decibel bylaw to planning is presented in Chapter Six.

Aircraft noise is not considered in the bylaw because of problems involving federal jurisdiction and the problems of deciding which authority - the engine manufacturers, the aircraft manufacturers, the airlines, or the airport operator (in this case, the City of Edmonton) - is responsible for the production of noise. "In most jurisdictions, public airports are considered of sufficient value to the general good to be regarded as legal or privileged nuisances"

(Minnesota Law Review, 1968, p. 1087). A more detailed examination of the legal problems of aircraft noise is presented later in this chapter.

5.1.1.3. Zoning Bylaws

Babcock (1966, p. 125) defines zoning as "part of the political technique through which the use of private land is regulated". Zoning is regulatory because it controls and guides urban development. Consequently, zoning legislation should be related to a comprehensive or general plan which describes the desired trends for future development. Relating the zoning bylaw to a general plan will tend to "minimize distinctions based on the ownership of a particular piece of land and to magnify considerations of general application" (Leary, 1968, p. 405).

The traditional method used by zoning to develop a city in which incompatibility between activities is minimized is to separate the different activities into zones. The three general classes of activities are residential, commercial, and industrial. This approach to planning for urban noise may be remedial or preventive. To restore compatibility between two activities involves a conversion from one land use to another and the costs of such a remedial action may prove prohibitive (McGrath, 1969). Preventive planning is achieved by zoning activities in such a manner as to avoid or minimize future noise problems.

Planning considers market forces, available government controls, public expectations, and technical information (McGrath, 1969). Metronoise must be examined in terms of all these factors. The economic costs and benefits of noise, the need for more meaningful legislative control of noise, the changing attitudes of the public concerning noise and the increased availability of technical expertise must all be incorporated if the escalating noise problem is to be halted.

The trend today in legislation concerning urban noise is towards a re-defining of the old vague verbal judgements from common law. As a city develops problems arise which are difficult to solve using these out-dated decisions. Statutory law has enabled these problems to be tackled, in the light of 'the scientific knowledge of the time', and it is hopeful that 'ordinary physical comfort of human existence ... according to plain and sober and simple notions' may become an established fact of our cities.

5.1.1.4. Aircraft Noise and the Law

The legal theory of nuisance has been used as a basis for aircraft noise suits but the lack of success of this theory is shown by the fact that of 27 public and military airport cases in the last ten years in the United States in which damages were recovered, in only two cases was the nuisance theory considered a proper basis for

recovery (Kaufman, 1969, p. 328). The reason why nuisance has not been a successful method in the abatement of aircraft noise is given by L.M. Tondel in his report to the President's Jet Aircraft Noise Panel (1966):

> ... where a public or quasi-public enterprise, like a railroad, or a power plant or gas works, or a sewer system, or any irrigation system, or thruway or an airport, or the like, is expressly authorized by legislation, nuisance claims that arise out of its proper operation are to be denied. The theory is that even if the activity in question would, if privately conducted, constitute a nuisance, it has been legalized by the legislative body which, within constitutional limits, authorizes the particular conduct on behalf of the public.

Another common law theory used in aircraft noise suits is that of trespass. Prior to the age of the aircraft <u>ad coelum</u> theory extended a landowner's property to the universe. After the introduction of commercial flight this theory was discarded and airspace considered a 'public highway' (Kaufman, 1969, p. 328). If depreciation in the use of one's property due to aircraft overflights can be shown then compensation may be obtained.

Statutory regulations are more useful in abating noise because they are enforced by a government authority. The private citizen is not required to prove that negligence or disturbance has occurred. Also, statutory legislation permits an active planning program by allowing the authority to enforce new standards based on the ever-increasing knowledge of the social and technical aspects of noise.

5.1.2. Industrial Noise Legislation

A responsible and socially-oriented government recognizes that an individual should be ensured of working in an environment which will offer minimum risk to his personal well-being. If damages are incurred by the worker due to a fault of his employer then compensation should be provided.

5.1.2.1. Federal Industrial Noise Legislation

The Canada Labour (Safety) Code, Department of Labour, is the federal legislation designed to protect those workers employed in industries and businesses which are under federal jurisdiction and in certain Crown corporations such as the Polymer Corporation Limited and the St. Lawrence Seaway Authority. The Safety Code also applies to air transport and airports and any activity which parliament has declared as "being for the general advantage of Canada, or for the advantage of two or more of the provinces" (Canada Labour (Safety) Code, 1966, p. 548). Such activities include uranium mining and processing, grain elevators, flour and feed mills and feed warehouses.

Regulations respecting noise control and hearing conservation were made pursuant to the code in 1970 and therefore represent the most recent concern about the noise problem in industry by the federal government. (The federal government has not instituted specific regulations concerning urban noise but has given the responsibility to the

provinces and municipalities.) One of the proposed regulations is that the sound level in any workplace shall not exceed 90 dBA and that in the speech range (500 - 2,000 Hz) the level shall not exceed 85 dBA. If the employer cannot reduce the noise then the workers are allowed a maximum exposure time per work shift as follows:

Sound Level (dBA)	Maximum Duration Per Day in Hours
90	8
92	6
95	4
97	3
100	2
102	1 1/2
105	1
110	1/2
115	1/4
140	0

Offences under the code are punishable on summary conviction, similar to municipal bylaws, and a fine not exceeding five thousand dollars and a maximum of one year imprisonment are provided by the code (Canada Labour (Safety) Code, 1966, p. 556).

5.1.2.2. Provincial Industrial Noise Legislation

In April 1968 the Legislation Branch of the Department of Labour prepared a report concerning all existing industrial noise legislation in Canada and it is from this report which the following facts are taken (Langford, 1968).

Newfoundland, Prince Edward Island, and Saskatchewan do not have serious industrial noise problems and have as a consequence no need to set regulations. If a noise problem

is discovered an industrial health inspector will discuss it with the employer but no law exists which empowers the inspector to enforce abatement.

In Nova Scotia the situation is similar although under the Industrial Safety Act of 1965 and the Construction Safety Act of 1967 regulations can be made to cover noise hazards. This province has increased the number of industrial noise surveys, medical checkups for early hearing loss detection have begun, and in some cases hearing aids and a pension fund are available.

The British Columbia Accident Prevention Department of the Workmen's Compensation Board provides for an educational program which circulates literature and organizes seminars on noise. Regulations exist which require workers to protect their ears and the British Columbia Mines Regulation Act states that management must take all reasonable measures to reduce noise levels and if this fails then protective devices must be supplied. This legislation fails to reduce the noise levels because management may simply say that it is impossible and they cover the workers' ears which in the long-run is not desirable.

In hazardous situations in Manitoba and New Brunswick the legislation recommends that workers wear protective covering. The number of hearing loss claims has been increasing and legislation is now being prepared to deal with the noise situation in industry.

In Quebec noise surveys were begun in 1963 by the Division of Industrial Hygiene of the Department of Health. After evaluating hearing loss claims the Health Department is required to make recommendations to the Workmen's Compensation Commission on how to reduce the hazard by such techniques as isolation of the worker from the noise, barriers, ear muffs, and limited exposure. No specific legislation exists although the Division recommends pre-employment and periodic audiometric testing in industry. Hearing loss claims increased from three in 1965 to ten in 1966 to twenty-five in 1967.

In Ontario noise control is the concern of the Department of Health, Industrial Hygiene and Labour. Twenty to fifty surveys are conducted each year by the Industrial Safety Branch of the Department of Labour and it is dependent on the inspector what measures must be taken to control the noise. The 1967 Report of the Royal Commission on the Workmen's Compensation Act (McGillivray Report) recommended "that further study regarding permissible sound levels in industry be made and that allowances for vertigo, headaches, and other complaints in case of bilateral deafness be increased" (Langford, 1968, p. 4).

In Alberta noise control legislation is found under the Public Health Act. Included in the act is a graph showing the maximum sound pressure levels to which a worker may be exposed each day and is similar in requirements to that

of the Canada Labour (Safety) Code. If the noise cannot be reduced and if the worker cannot be isolated from the noise the worker must be fitted with hearing protection equipment at the employer's expense.

5.2. Recommendations for Further Noise Abatement Legislation

> Despite the growing need for effective noise control, existing legal remedies have proved to be inadequate. Nuisance remedies and longstanding comprehensive noise ordinances have not performed satisfactorily. Recent legislation, embodying modern scientific concepts, has had only limited efficacy. Ultimately, the only satisfactory method of noise control may result from market pressures on the manufacturers of noise producing items or from particularized regulation of specific noise producing sources.
> (Columbia Journal of Law and Social Problems, 1968, p.105)

Accepting the present law structure, much can be accomplished in reducing urban noise. To state that social change can only be achieved through economic pressures indicates a basic distrust in the ability of a democratic system. Baron (1970) proposes that noise abatement be recognized as an ideal which would serve as a point of orientation in decision-making. A government agency such as the recently formed Canadian Department of the Environment could define this 'ideal' by establishing and enforcing noise abatement guidelines, codes, and regulations.

Community surveys, such as the one employed in this thesis, could be used by this agency and a data bank developed which could identify which noise sources at which times and at what levels are responsible for complaints in any

type of neighbourhood. This data bank could also establish an ambient noise climate associated with any type of urban land use, ranging from residential areas near airports to industrial to suburban residential. Having possession of this information, the agency, with the aid of its power of enforcement, could plan the siting and acoustical design of new structures and operations for a community.

The Columbia Journal of Law and Social Problems (1968, p. 119) concludes its study of urban noise legislation:

> The problem of the increasing menace of urban noise must be faced now. The ineffectiveness of present solutions in handling the threat, whether because of lack of proper standards or the impossibility of enforcement, demands a re-evaluation of our present legal structure. The first step in the process of re-evaluation must be a thorough investigation of the effects of different levels and kinds of noise on the physical and mental health of the hearer. Future laws must take into account the degrees of social value of different noise producing activities in providing for control and abatement of urban noise. There must be greater cooperation between government and industry to develop standards and advance the technology with which to enforce and meet those standards. The most important task, however, is to make the public aware that offensive noise can be controlled, and angry enough to do something about it. Without the active support of the public, all the planning and programming, all the conferences and statements by public officials are little more than 'so much noise'.

CHAPTER SIX

PLANNING WITH RESPECT TO NOISE

Leary (1968) states that one of the basic concerns of urban planning is the promotion of the health, safety, convenience, and welfare of the public. An objective of urban planning is the designation of certain urban activities to certain areas of the city in order to achieve compatibility between the activities. Compatibility between a residential area and an industry characterized by heavy smoke and fume emissions may be achieved and maintained by locating the residential units on the windward side of the industrial operation. Factors other than wind direction, which cannot usually be assumed as a constant, must be recognized and considered in the location decision. Locating a hospital in close proximity to an airport may not be conducive to the patients' well-being in terms of noise and safety. Recognizing the relationships between urban activities and deciding which activities may co-exist favourably are two major steps in the planning process which ultimately attempts to achieve public welfare.

The planning process requires legal controls to enact needed changes and protect against undesirable changes within the urban scene. Amongst such controls are:

Building codes, which legislate against poor quality materials and methods used in construction and ensure that the dwelling or workplace is safe for the occupants.

Nuisance bylaws, which legislate against the production of obnoxious odours, fumes, noise and other products of urban activity which are considered deleterious to public health and safety.

Zoning, which is a technique used by planning authorities to contribute to the establishment and proper maintenance of proposed developments.

To ensure the usefulness and applicability of these legal techniques as noise control and abatement measures, one should not concentrate on the use of one method to the exclusion of the others. Many factors are involved in the urban noise problem and only through a co-ordinated use of all available legal and technical expertise may a solution be found.

6.1. Planning with Respect to Traffic Noise

Many factors decide the manner and the extent to which an individual is disturbed by traffic noise. Knowledge of these is essential in developing effective traffic noise controls.

Although the noise levels existent within a house are influenced by several factors, a major determining factor is the amount of noise emitted by the noise maker which,

in this case, is the motor vehicle. Control of this source of noise may be attempted by means of the nuisance bylaw. If the limits designated in the bylaw are the result of scientific research and if they are enforced strictly, then a significant decline in traffic noise may be achieved.

The Edmonton noise bylaw (1971) sets a maximum noise level of 83 dBA on passenger vehicles and trucks having a gross weight of less than 6,000 pounds. This is the level as measured fifteen feet from the vehicle (see Appendix VI). The National Research Council of Canada (1968) recommended a similar level prior to 1968 but suggested that a reduction in the permissible level to 80 dBA be instituted after 1969. Although the Edmonton bylaw limit restriction of 83 dBA does not conform exactly to the N.R.C. recommendations, it is adequate legislation and represents a realistically enforceable limit.

The permissible limits for motorcycles, as stated in the bylaw, are 88 dBA during the day and 83 dBA at night. These levels are lower than the N.R.C.'s 1968 levels of 90 dBA and 85 dBA, respectively. However, they are higher than the council's 1969 revised levels of 85 dBA and 82 dBA. Since it is reasonably possible to reduce motorcycle noise to a maximum of 85 dBA it is suggested that the bylaw be reviewed and a reduction introduced into the bylaw.

With reference to vehicles with a rated gross weight in excess of 6,000 pounds the N.R.C.'s maximum noise level

of 87 dBA compares to a 90 dBA level in the bylaw. A reduction in the latter level is suggested.

A resident is not allowed, under the bylaw, to make a noise greater than 65 dBA, as measured at the property line, during the day unless it is intermittent in nature. The maximum time limits on intermittent noise greater than 65 dBA is two hours for 70 dBA, one hour for 75 dBA, thirty minutes for 80 dBA, and fifteen minutes for 83 dBA. At night, a resident cannot make a noise in excess of 50 dBA. These levels effectively restrict the noise emitted by motor vehicle horns, lawnmowers, power tools, model airplanes and other residential noise makers.

The above daytime limits on residential noise are not useful as control limits on snowmobile noise. This is mainly attributable to the mobility of the snowmobile which renders the bylaw difficult to enforce. The bylaw may be used to effectively control snowmobile noise, however, if the 50 dBA limit on residential noise production is interpreted as meaning that a resident may reasonably expect not to be exposed to a noise, inside his property line, in excess of 50 dBA. The zoning of snowmobile use to specific areas of the city may be the best method for banning this particular noise maker.

Monitoring noise, as a step towards the enforcement of the bylaw, is a major problem. Monitoring vehicles along the roadside is one method of determining the noise output

of a vehicle. Contemporary noise measuring equipment is not capable, however, of isolating a noisy vehicle from a group of vehicles. In this instance, monitoring will result in a measure of the ambient noise level, similar to the measurements performed by the author, and will not be a measure of the noise output of one individual motor vehicle.

Another method of monitoring motor vehicle noise is that of requiring the driver of a suspected noisy vehicle to report to a vehicle inspection unit at which point the noise producing capabilities of the vehicle are assessed. Since vehicle noise may be directly related to driver competence and not to the engine, this method does not contribute significantly to the abatement of traffic noise.

Until it can be proven, with reasonable certainty in a court of law, that a vehicle, operating under actual operating conditions, produced a noise level in excess of the permissible level, as stated in the bylaw, the law will remain difficult to enforce and therefore, unsatisfactory as a noise abatement control method.

Nuisance bylaws are remedial measures in that they attempt to correct an already existing condition. They are useful as a preventive measure by indicating to the vehicle manufacturer the levels allowed within a particular city. If the bylaw cannot be enforced, for lack of reliable evidence, the profit-motivated manufacturer will not be inclined to invest money for the design and installation of noise reduction accessories. Government vehicles could be fitted

with noise reduction equipment such as total engine enclosures and this would serve as an example to the public who would, in turn, hopefully, pressure the manufacturer into supplying similar equipment on his vehicles. Some state and provincial governments are presently equipping vehicles with air pollution equipment in the hope that this will serve to educate the public and create a demand for such equipment.

The amount of traffic and character of the traffic flow determines ambient noise levels. Streets were classified, in Chapter Three, as 'noisy' and 'quiet'. The condition of noisiness was directly related to the traffic flow and whether or not transit vehicles and trucks utilized the street. These two factors of traffic noise, flow and character, may be used to great advantage by planning authorities. For example, in Edmonton trucks and transit buses are restricted to certain streets. The decision to designate streets as heavy vehicle routes should involve consideration of the possible noise levels that will result from that use. A cost-benefit analysis should consider the balance between travel and operating costs and the social cost of resulting noise and disturbance. It may be found by such analysis that the benefit of using a street to decrease travel time between two points is out-weighed by the social costs due to noise. A reclassification of the street should be made accordingly.

The restriction of vehicles to certain streets during

daytime hours may lead to a reduction in the noise environment along those streets although the noise level may increase along the alternate nighttime routes. Such time restrictions could be used to advantage near hospitals and schools.

The road gradient and the distance between the road and house also determine noise levels within the bordering houses. Gear noise and brake noise are major components of traffic noise along hills as well as at intersections. The planning of new routes should consider the factor of gradient although steep streets should not be levelled if it would be inconsistent with the general character and topography of the community.

Use of embankments and entrenched roads serve to reduce the noise level received at the residents' ears. Where land is at a premium embankments and retaining walls are suggested noise attenuation features, although visual intrusion may become a serious problem. Foster and Mackie (1970) found that a depressed roadway is less expensive to construct and achieves greater noise attenuation than an elevated roadway with retaining walls. Incorporation of such features, as a remedial action, in presently existing communities offers a challenge to the imagination and ingenuity of the planner.

Zoning of residential units may be employed to reduce noise levels. Rather than having the house face onto the

street, an increased reduction in the ambient noise level within the house could be achieved by placing the backyard between the house and street. Houses may be placed on the lot in such a manner that those rooms experiencing the most family activity are located away from the street.

Buildings not sensitive to noise may act as barriers between traffic noise and residential units (Foster and Mackie, 1970). These buildings may range from light industrial complexes to garages. As shown in Chapter Three, a maximum attenuation of 15 dBA may be expected through the use of shielding (Wiener et al., 1965) and therefore, may contribute significantly to a reduction in residential noise.

The building code may be designed to incorporate noise attenuation designs although this action is similar to supplying a worker with ear muffs in that a solution to the total noise problem is not achieved. A closed single pane window attenuates outside noise by 20 dBA whereas a 40 dBA reduction is gained by the use of a sealed double window (Foster and Mackie, 1970). The cost of installing double windows may be as high as $70 and in most cases a ventilation system would be required which, in turn, would represent an expense to the homeowner. As a general recommendation, research should be conducted to determine the amount of noise attenuation desired in each type of residence and detailed performance standards written into the building code.

Reduction of traffic noise to tolerable levels is possible with contemporary techniques. The role of the planner is to evaluate the methods of traffic noise reduction and select those solutions which will produce the greatest benefits to society at the least costs in terms of health and welfare.

The costs of noise to society does not need to be measured in monetary terms in order to evaluate the feasibility of operation of a noise maker. The disruption of community life because of low-flying aircraft may be very evident. To attribute a monetary cost to this disruption is not only extremely difficult but also a misdirected exercise. Planning must develop a scale of human response to noise ranging from absolute silence to 'ear-shattering' noise. This scale could then be used to classify city areas according to the intended activity and the ambient noise levels. Perhaps, accessibility would be inversely related to individual response to noise. It may be found, for example, that in a high population density area such as in an apartment complex, the decision of the resident to live there is more positively influenced by a desire for mobility and proximity to work and recreation than the desire to live in a quiet, self-contained house in the suburbs.

6.2. Planning with Respect to Aircraft Noise

Alleviation of the aircraft noise-community disturbance problem involves two basic approaches; reduction of

the amount of noise produced by the aircraft and separation of the resident from the noise.

Aircraft engine manufacturers are developing new generation high-bypass ratio engines which produce less exhaust noise and pure-tone noise with the remaining noise being predominately fan noise (Tyler, 1969). These manufacturers suggest that a slow rate of decrease in noise production will continue over a period of years and predict no radical change in noise attenuation design.

Faced with a continuation of aircraft noise the other approach to its abatement, separation of the resident from the noise, must be actively employed. Two planning groups, one planning within the city and one planning within the airport, are independently attempting to achieve this ideal separation of man and noise. The absence of meaningful legislation dealing with aircraft noise and a lack of co-ordination between the two planning groups is made apparent by the increasingly major problem posed by aircraft noise within our cities. A commonly stated suggestion for airport development is to locate the facility away from the urban area. Although such location would eliminate the noise levels associated with the airport, other problems would arise. One of the most desirable aspects of air transport is its ability to provide high speed transport of goods. Locating the facility away from the people to be served increases the time factor in ground transportation and therefore, decreases the competitive ability of the

facility.

> The growth of urban centres in the western world has far outpaced the development of facilities to serve them. This is particularly true of transportation facilities. Every transport mode is vital to an urban centre. Yet, in virtually every major complex in the western world, transportation systems are inefficient and inadequate. As a result, there is congestion and delays in the movement of people and goods in both inter-urban and intra-urban systems.
> (Darden and Khan, 1970, p. 191)

The proper planning of an airport and its operations will both enhance the benefits and reduce the costs to society.

The following sections examine the possible future actions which may be taken by urban and airport planners to alleviate this factor of metronoise.

6.2.1. The Role of Urban Planning in Alleviating Aircraft Noise

Traditional zoning, because of its orientation to classified land uses, is limited to remedial action. Traffic and aircraft noise pervade all areas of the city and this metronoise cannot be controlled by means of these traditional zoning techniques. The relationships between the airport activity and the resident must be a consideration in the evaluation of any planning dealing with land uses in the vicinity of airports. The concept of the Composite Noise Rating measures this relationship and enables the co-ordination of the two planning groups.

Guild et al. (1964) have classified CNRs into zones on the basis of residential response to aircraft noise.

In areas less than 100 CNR (Zone 1) no complaints are expected. Individual complaints and possible group reaction are expected in Zone 2 (100 to 115 CNR) and in Zone 3 (greater than 115 CNR) individual and group reaction in the form of repeated and vigorous complaints are certain to occur. The assessment of individual reaction to noise on which these classifications are made is based on the assumption that complaints represent the feelings of the whole community. The validity of this relationship between the individual and the community was examined in Chapter Four.

In addition the reliability of the zonal classifications is supported by a comparison of Speech Interference Levels (SILs), PNdB levels, and CNRs. The threshold of annoyance for living rooms is between 75 and 80 CNR and accepting a value of 20 dB for building attenuation, complaints begin between an outside CNR value of 95 and 100 (Donato, 1970). The SIL for an average living room is 43 dB which corresponds to a PNdB level of 63 and a CNR of 73 (Donato, 1970). The outside CNR of 100 therefore represents the maximum permissible noise level for indoor communication and may be termed 'moderately noisy'.

Surveys in England (Committee on the Problem of Noise, 1963) and in the United States (International Civil Aviation Organization, 1969) have found that the separation level between Zones 2 and 3 should be 110 CNR rather than 115 CNR. Donato (1970) maintains that the higher CNR was instituted

to avoid penalizing airport authorities at the time the zones were established. Around London Airport a depreciation of six per cent per year in residential property value corresponds to a CNR of 100 and in Germany no residential building is allowed in an area within the 114 CNR contour while in France no apartments or offices may be built in areas within the 115 CNR contour (Donato, 1970).

Guild et al. (1964, p. 723) stress that the community responses within each zone should not be used to "fix blame for existing situations on any aircraft operator, builder, zoning commission or other group ... that the new procedure provides the best technical guidance and assistance presently available for the prevention of future incompatible use of the land surrounding military, civil, and combined airfield facilities". It must also be realized that each city will have unique problems and that its population's reaction will vary according to a number of factors relating to personal attitudes and community characteristics (Bolt, Beranek, and Newman, 1964). Such factors include: the economic importance of the airport to the community, the presence of organized protest groups, the concern of those authorities responsible for controlling the noise, and the relationship between the noise problems and other municipal problems such as zoning and political jurisdiction.

Accepting these conditions, the Ontario Department of Municipal Affairs (1969), in conjunction with the Federal

Department of Transport, has developed a Land Use Compatibility Table which classifies CNRs into noise sensitivity areas and establishes criteria for land use development in each of these zones. Figure 6.1 outlines the noise sensitivity areas for Edmonton based on the CNR findings as described in Chapter Three. Table 6.1 lists the compatible land uses for each area. Since each land use represents a specialized problem and because of constantly changing attitudes and technology, explanatory notes by the Department of Municipal Affairs are presented in Appendix VII to assist in defining the appropriate remedial measures which should be applied in each case.

The establishment of the noise sensitivity zones, by allowing a uniform application of common criteria, represents a major advance towards solving the aircraft-community noise problem.

Figure 6.2 locates presently existing schools, hospitals, and nursing homes within the 100 CNR contour or those land uses which, due to aircraft noise, are classified as incompatible with airport activities. In addition, Figure 6.2 outlines the projected residential areas for 1981 in the vicinity of the Industrial Airport, as outlined by the Edmonton General Plan (1967). It is obvious from the general plan's projections that noise was not considered as a major planning criterion. The establishment of light industrial and airport-oriented complexes within the 100 CNR

Figure 6.1

Noise Sensitivity Zones around Edmonton Industrial Airport

TABLE 6.1. COMPATIBLE LAND USE TABLE

(Ontario Department of Municipal Affairs, 1969)

Noise Sensitivity Zones	I	II	III	IV	V
Composite Noise Rating	Greater than 115	115-110	110-105	105-100	Less than 100
LAND USES					
1. <u>Agricultural</u>					
Crop Farms	YES	YES	YES	YES	YES
Market Gardens	YES	YES	YES	YES	YES
Plant Nursery	YES	YES	YES	YES	YES
Tree Farm	YES	YES	YES	YES	YES
Stock Yards	K	YES	YES	YES	YES
Dairy Farms	K	YES	YES	YES	YES
2. <u>Commercial</u>					
Aircraft Sales	YES	YES	YES	YES	YES
Schools	F	F	YES	YES	YES
Repair	YES	YES	YES	YES	YES
Auditoriums	NO	G	G	G	E
Banks	NO	NO	F	YES	YES
Warehouses	YES	YES	YES	YES	YES
Gasoline Stations	YES	YES	YES	YES	YES
Garbage Disposal	YES	YES	YES	YES	YES
Hotels and Motels	G	F	F	F	YES
Office Buildings	M	F	F	F	YES
Parking Lots	YES	YES	YES	YES	YES
Restaurants	NO	F	F	F	YES
Stadiums	NO	NO	NO	YES	YES

Noise Sensitivity Zones	I	II	III	IV	V
2. Commercial (Cont'd)					
Shopping Plaza	F	F	YES	YES	YES
Terminal Buildings					
Bus	F	F	YES	YES	YES
Train	F	YES	YES	YES	YES
Airlines	F	F	YES	YES	YES
Truck	YES	YES	YES	YES	YES
3. Industrial					
Factories	L	L	L	YES	YES
Coal Yards	YES	YES	YES	YES	YES
Machine Shops	L	L	YES	YES	YES
Rail Yards	YES	YES	YES	YES	YES
Cement Plants	YES	YES	YES	YES	YES
Quarries	YES	YES	YES	YES	YES
Refineries	YES	YES	YES	YES	YES
Lumber Yards	YES	YES	YES	YES	YES
Sawmills	YES	YES	YES	YES	YES
4. Recreational					
Athletic Fields	NO	NO	NO	YES	YES
Fairgrounds	NO	NO	YES	YES	YES
Golf Courses	YES	YES	YES	YES	YES
Parks and Picnic Areas	P	P	YES	YES	YES
Playgrounds	P	P	YES	YES	YES
Tennis Courts	P	P	YES	YES	YES
Outdoor Theaters	NO	NO	NO	NO	G
Swimming Pools	YES	YES	YES	YES	YES
Racetracks (Horses)	NO	P	YES	YES	YES
Racetracks (Cars)	YES	YES	YES	YES	YES
Camping Grounds	NO	NO	NO	NO	YES

Noise Sensitivity Zones	I	II	III	IV	V
5. <u>Transportation</u>					
Highways and Railways	YES	YES	YES	YES	YES
6. <u>Municipal Utilities</u>					
Electric Generating Plants	YES	YES	YES	YES	YES
Gas and Oil Storage	YES	YES	YES	YES	YES
Garbage Treatment	YES	YES	YES	YES	YES
Water Storage	YES	YES	YES	YES	YES
Water Treatment	YES	YES	YES	YES	YES
7. <u>Residential</u>					
Detached and Semi-detached	NO	NO	C	B	A
Town houses and Maisonettes	NO	NO	B	B	A
Apartments	NO	D	B	B	YES
8. <u>Public Facilities</u>					
Churches	NO	NO	NO	F	E
Schools	NO	NO	NO	F	E
Hospitals	NO	NO	NO	F	E
Community Centres	NO	NO	NO	F	E
Cemeteries	YES	YES	YES	YES	YES

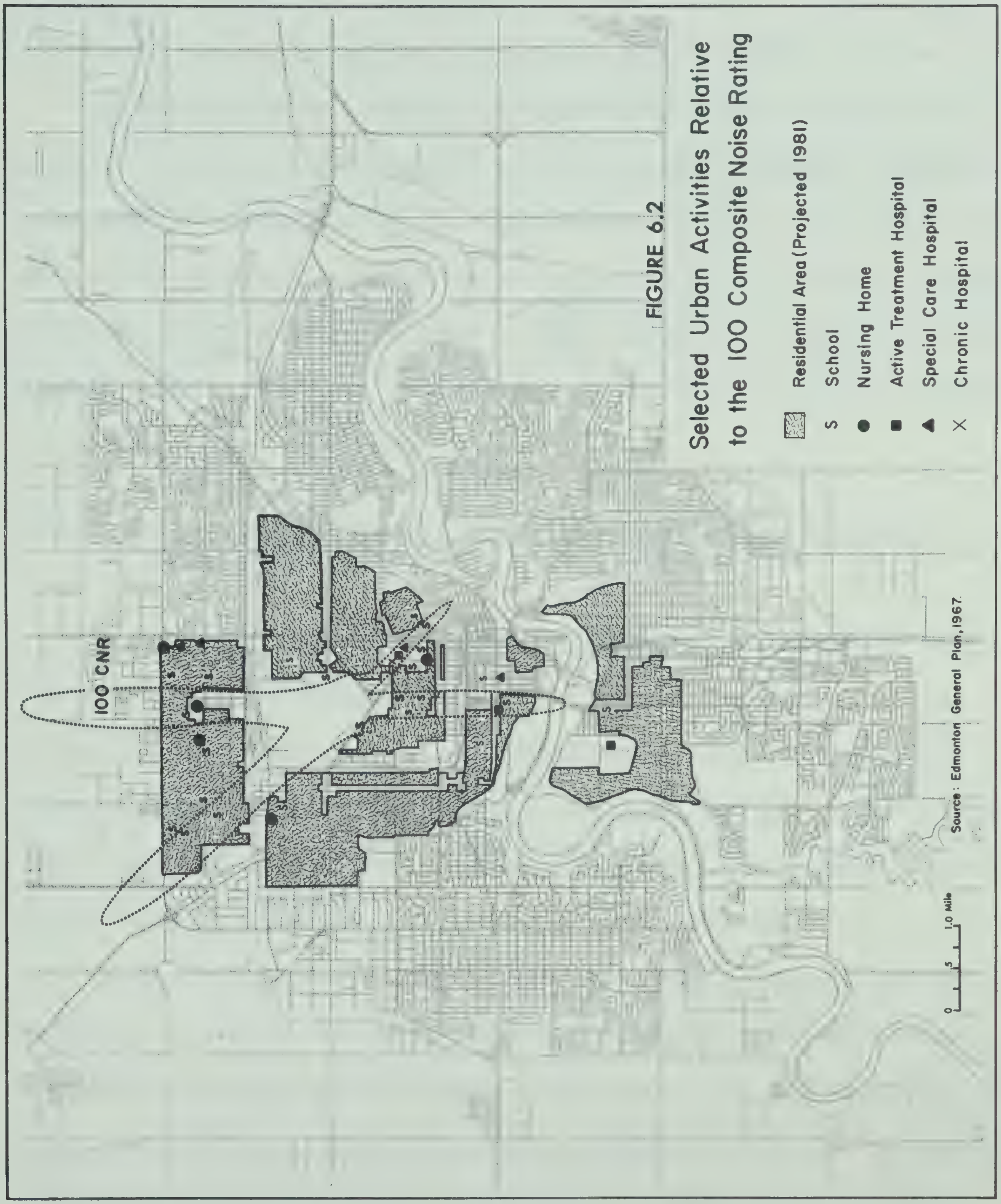


FIGURE 6.2

Selected Urban Activities Relative to the 100 Composite Noise Rating

Source: Edmonton General Plan, 1967.

contour would serve both as a buffer between the airport and residential units and as a revenue source for the city. A detailed study of the needs and desires of the city should be viewed in terms of the land use compatibility tables.

Accepting the aircraft manufacturers' statement that a major reduction in noise levels from contemporary engines will not be achieved in the immediate future, it is unrealistic and naive for planners to promote such projections as outlined in the general plan. This document simply promotes an existing situation and offers no attempt to direct change in terms of the citizens' needs.

6.2.2. Airport Planning's Role in Alleviating Aircraft Noise

The planning of airport operations in terms of the CNR may contribute significantly to an alleviation of the noise problem and enable more meaningful land use projections in the airport vicinity to be made by the urban planner. Several techniques are available to the airport operators to aid in noise attenuation (Beranek, 1969).

The requirement for pilots to reduce thrust and to climb at a lower rate when above a minimum safe altitude and when over populated areas will result in a reduction of the area of the noise foot print and therefore, in the number of people exposed to the noise. A similar reduction may be achieved by requiring aircraft to turn away from residential areas during the climb-out phase of take-off.

Pilots prefer not to operate under these restrictions. The reasons for this are given by the Air Line Pilots Association which states the following:

> A large reduction in noise level implies a large reduction in thrust which, in turn, means a substantial engine response time. In the event that an evasive manoeuver was required, the engine response time would be detrimental to the success of the manoeuver. The consequences of an engine failure in this reduced thrust condition can be hazardous.
>
> (Tondel, 1966, p. 102)

An industrial activity could be planned in relation to an airport in such a manner that the majority of the take-offs would take place over this particular land use and avoid exposure of residential areas. In Edmonton an emphasis on industrial land uses north of Runway 34, south of Runway 16 and northwest of Runway 29 would allow present airport operations to continue without presenting the danger of engine failure referred to above.

The designation of preferential runway systems will direct aircraft away from certain areas of the city. At the Edmonton Industrial Airport concentrated use of Runway 34 for take-off would contribute to a significant reduction in noise exposure in the area south of the airport. The fact that modern aircraft can take-off and land with maximum cross-winds of 20 knots (Sawyer, 1967) allows such runway use concentration. Although this technique of designating preferential runways is of limited use in existing airports it should be considered when constructing a new airport or expanding the facilities of an existing airport.

The CNR values may be reduced by instituting limits on the number of nighttime operations. As shown in Chapter Three, nighttime operations, defined as operations between 2200 hours and 0700 hours, were minimal in Edmonton during the summer of 1970. However, a decrease in CNR values may be achieved by re-defining night operations as those which take place between 2100 and 0800 or 0900 hours. This extension of nighttime hours would reduce the occurrence of sleep disturbance caused by noise. In addition, maintenance run-ups during these hours could be restricted.

The major obstacle in instituting the above changes in aircraft operations to alleviate noise levels is that of cost, the decision on who is to pay the cost. Beranek (1969, p. 268) recognizes cost as a principal factor prohibiting action at United States airports.

> Who is to pay the piper? To date (1969) there has been no objective economic evaluation of the benefits and costs of reducing noise in order to allocate the burden properly. But, at the moment, the specter of billions of dollars being spent by the Federal government has effectively put the brakes on necessary action.

A similar situation exists in Canada. Restricting operations to daytime hours may introduce delays in an airline's service. Similarly, the use of preferential runways may cause delays and increase operation costs. The costs of such delays must be identified and evaluated.

Public need in relation to costs must be evaluated. As this study has shown, the public is becoming more dissatisfied with the by-products of this service industry and are

beginning to accept the fact that a cost must be incurred in order to eliminate its undesirable side effects. A basic realization should be made that the economic and technical aspects of urban development no longer merit absolute priority in decision-making but rather, that social or human factors must be given more consideration.

6.2.3. Future Airport Development

In 1969 the Edmonton Industrial Airport ranked as the seventh busiest airport in Canada with 202,027 aircraft operations (Appendix VIII). Of this total, 86,388 operations were termed 'itinerant' or those flights which leave or enter the Industrial Airport tower control zone. When compared to the Edmonton International Airport, which ranked 28th in Canada in 1968 with a total of 37,265 movements, it is apparent that the Industrial Airport is fulfilling a vital role in the economic structure of Edmonton (Edmonton Regional Planning Commission, 1969). Several problems, however, present themselves to the future operation of the airport in its present state.

The encroachment of tall buildings has caused a reduction in the effective usable runway lengths from 5,700 feet to 5,160 feet for Runway 16, 5,868 feet to 4,681 feet for Runway 11 and 4,446 feet to 3,776 feet for Runway 21 (Edmonton Regional Planning Commission, 1969, p. 17).

The reduced safety margin associated with the above runway restrictions as well as the increased noise levels,

partly attributable to an increase in jet movements (1,259 in 1966 to 3,623 in 1968) have resulted in a rise of public pressure against the airport, as witnessed by the petition discussed in Chapter Four. An 'anti-airport' group believes that greater revenue could be obtained for the city by using the airport land for other uses such as a sports-convention centre complex or industrial park. This group proposes the establishment of an airport away from the city-centre and connected to the latter by means of a rapid transit system. The history of airport development shows that such city-airport separation does not persist because of encroachment by aircraft-oriented industries. These industries in turn influence the development of residential areas in the vicinity of the airport. The result is an airport with low capacity and poor accessibility, the very problems which originally forced the airport to relocate.

The recent development of the STOLport promises improved capacity and accessibility without moving from the city-centre. The short-take-off and landing (STOL) and vertical-take-off and landing (VTOL) technology enables the retainment of city-centre airports, such as the Edmonton Industrial Airport, because of several factors.

Present STOL aircraft operate on runways less than 2,000 feet in length and future models may require less than 800 feet of runway. These lower operating lengths reduce the demand for costly city-centre ground space. They may

operate on presently existing navigation systems and are more flexible for low altitude operations around tall structures. The noise foot print, as a result, is much smaller in area. This is evident in Figure 6.3 which outlines the PNdB contours for the DHC-6 Twin Otter in STOL take-off.

Darden and Khan (1970) suggest that 52 per cent of the total travel time between city-centres is spent on ground transportation. A greater time saving will be achieved by the use of STOL and VTOL equipment in conjunction with rapid transit at existing airports than by establishing rapid transit connections between the city-centre and 'outer-city' airports.

The employment of STOL and VTOL aircraft will ensure that the Edmonton Industrial Airport will remain an economically viable activity. The airport and city resident will become more compatible with respect to noise and safety and hence, community and political acceptance of the airport will ensue. The drastic changes in residential land use planning discussed earlier in relation to conventional take-off and landing (CTOL) aircraft would not be necessary with STOL and VTOL aircraft. Although residential areas would be more compatible in terms of noise with the STOLport it would still be necessary for the urban planner to carefully cross-check his efforts "with pertinent governmental authorities, particularly in the area of air traffic control, obstruction clearance and zoning protection. Potential

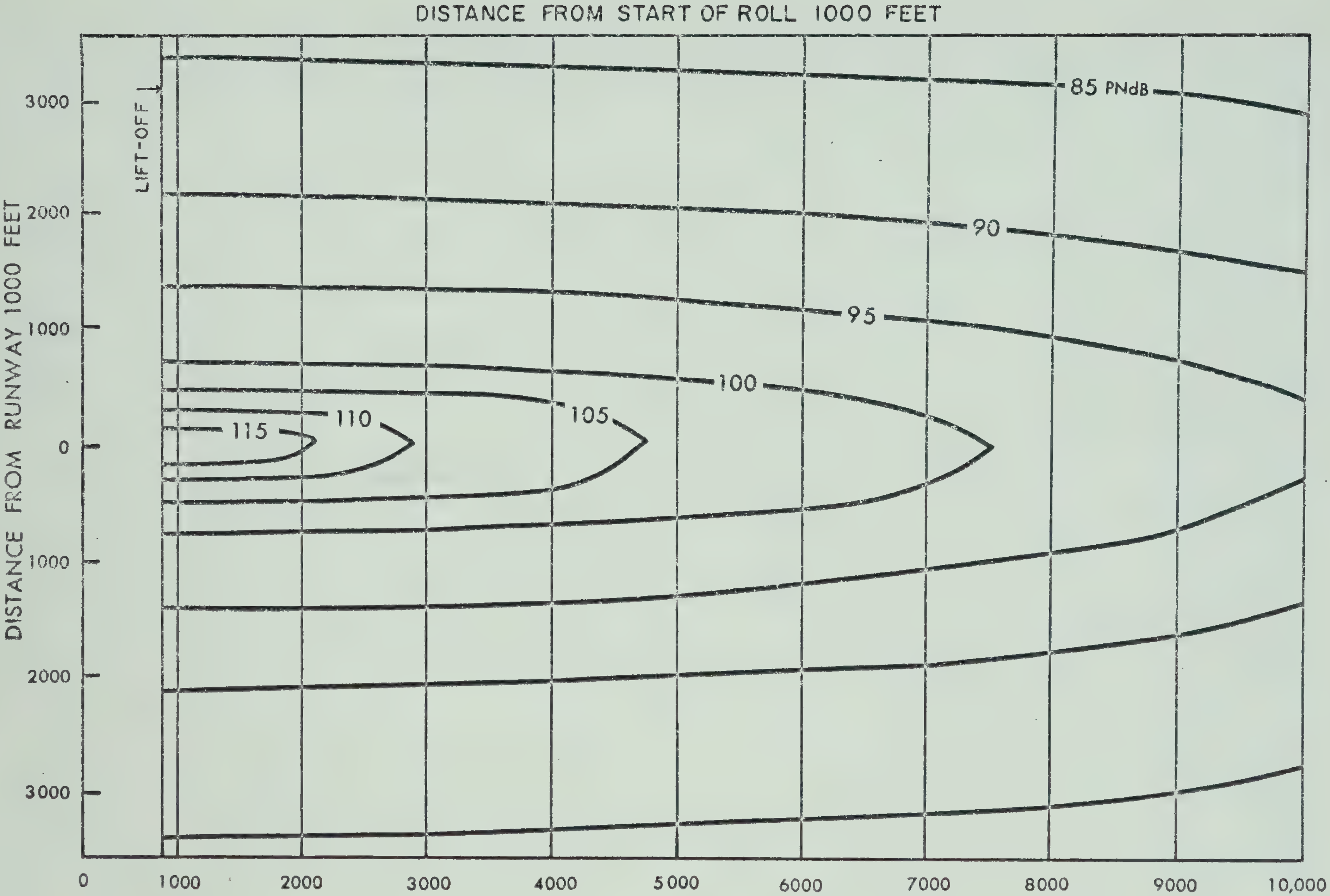


Figure 6.3. Perceived Noise Level Contours for DHC-6 Twin Otter in STOL Take-off.

SOURCE: BOLT, BERANEK & NEWMAN, INC., 1969.

operators must be brought in at every phase of the planning effort if the project is to be economically viable and attractive to investors" (Darden and Khan, 1970, p. 196).

CONCLUSION

Noise is considered by many urban dwellers today as airborne blight. Sleep is disturbed by passing motor vehicles, conversation is interrupted by low-flying aircraft and an increasing number of industrial workers are seeking compensation for loss of hearing. This thesis has attempted to shed some light on this particular form of environmental contamination. With a thorough understanding of noise man will be better prepared to create the ideal complex of social and physical conditions most conducive to the development and betterment of the individual within his community.

The physical properties of sound, frequency and pressure, are major determining factors in the perception of noise. High frequency sounds, such as the whine of a jet engine or the squeal of skidding tires, are perceived as noisier or louder than lower frequency sounds of the same pressure. The dBA and PNdB scales have been developed to account for the influence of frequency on the subjective noisiness of motor vehicle noise and aircraft noise, respectively.

A discussion of the nature of the motor vehicle and aircraft as noise sources was presented in Chapter Two. Combined with information on the operating procedures of these two noise producers, it was possible to map the spatial

extent of the noise within Edmonton. Information on the ambient noise levels obtained from 21 sites was projected to other areas of the city. A detailed study of at least an additional 100 sites employing automatic sound measuring equipment on a 24 hour basis is suggested in order that the validity of such extrapolation as was used in this study may be tested.

The frequency and pressure of a sound at the ear are not the only factors influencing how the listener will perceive and react to that sound. The number of times the sound occurs within a given period of time and the duration of the sound will affect the final perception of it as a noise. The Composite Noise Rating, as described in Chapter Three, classifies aircraft noise according to the time of occurrence and the frequency of occurrence and relates these to the noise level as measured on the PNdB scale. The Composite Noise Rating is based on average PNdB levels, atmospheric conditions and aircraft operating procedures. Further research is required in the areas exposed to aircraft noise due to changes in the weather conditions, variations from the assumed flight paths and pilot preference. Also, human activities change with the season of the year. This study was concerned only with summer conditions. Research on noise perception during the winter months may enable planning authorities to initiate seasonal variations in their noise control requirements.

Similar relationships exist between motor vehicle

noise levels, time of day of the noise, duration and frequency of occurrence and the listener. In Chapter Three city streets were classified into noise groups according to the type and volume of vehicle flow. The decision that a street was either 'noisy' or 'quiet' is a beginning in noise planning. However, more information on noise levels as related to volume of vehicle flow, height and attenuation characteristics of surrounding buildings, the width and grade of the street, and the activities engaged in along the street and within the buildings is required.

Other factors influencing the perception of noise, not accounted for by the above indices should be investigated, evaluated and included in the planning process. These include the attitudes, feelings, reactions and perceptions of the individual in his total social environment. The identification of the social needs and goals of a person and his community will determine what noises are undesirable, in what ways a noise is disturbing, and what are the features of a desirable noise environment. Such information could be used to anticipate community reaction to the introduction of a potentially noisy activity and thereby contribute to the credibility and reliability of planning decisions.

Chapter Four presented the results of a noise questionnaire survey which was conducted within Edmonton. Tolerance of a noise was found, in a few cases, to be tempered by the belief that the particular noise was a necessary by-product of a source producing a desired commodity or service.

Some residents appeared to adapt to an increasingly noisy situation. Intensive study of an individual's adaptation ability should be conducted and the findings combined with presently existing sociological indices such as the Composite Noise Rating. It was found that if a person was dissatisfied with his neighbourhood then noise would be included as simply another nuisance to be lived with. Interference with conversation, sleep, or the watching of television all decreased a person's acceptance of noise. In Edmonton annoyance with aircraft noise instigated the formation of an anti-noise petition by some of the residents living near the airport. These people felt that the powerful authorities responsible for the airport were deaf to their desires for a quiet and safe neighbourhood. Several of these same residents considered small aircraft operations a greater annoyance than the large jet aircraft, such as the Boeing 737. Analysis of the extent of the area exposed to noise from these small aircraft and the feasibility of relocating their operations to a rural setting should be undertaken.

Investigation of the noise levels in a hospital close to the Edmonton Industrial Airport revealed that the fear of crash outweighed the disturbance of patients and workers by noise. A greater in-depth questionnaire survey should be conducted to evaluate the relationships between the hospital activities and airport operations. It is strongly recommended that any intention to build a new hospital complex in the

vicinity of an existing airport be questioned. However, since hospitals are located in relation to the people they are intended to serve, fundamental planning must first consider the location of residential units in relation to airport activities.

Another institutional activity directly related to residential areas, and not examined in this study, is the school. The effects of noise on the concentration and learning ability of children within the school must be studied in detail and, in a planning decision, be given weight comparable to the findings relating to noise and hospitals.

Public concern for the physical environment has resulted in increased pressure for the legal control and abatement of noise. Chapter Five examined the present state of noise legislation which may be divided into two main categories, urban and industrial noise legislation.

The use of the common law as a nuisance action against an urban noise-maker has proven inadequate because of its basic lack of definition of nuisance. Also, the expense of litigation by a private citizen is prohibitive in most cases. Statutory law supercedes common law and has proven to be more successful in obtaining damages because it gives government the ability to enact and enforce desirable noise requirements and therefore, removes the onus of proof from the citizen. The public nuisance bylaw is a statute and is designed and enforced usually by the

municipal government. Provincial and federal noise legislation is oriented to the industrial worker and is not concerned with the citizen and urban noise directly. The city must first have provincial permission to enact a noise bylaw but it is the city which decides permissible limits and methods of control. Most municipal noise bylaws however, reveal a lack of definition and enforcement is consequently rarely achieved. The application of scientific noise research to these laws is proving a more valid and adequate method of controlling the urban noise situation than the previous vague verbal limits. The Edmonton Noise Bylaw, enacted in 1971, places realistically enforceable limits on motor vehicles, construction equipment and other residential noise producers. Problems of enforcing the bylaw were presented in Chapter Six. The use of a vehicle inspection unit and roadside monitoring techniques both have inherent difficulties in proving, with reasonable certainty, that a particular noise-maker produced a noise level in excess of the permissible level. Research is presently being conducted in several countries, including Canada, to solve these monitoring problems. It is suggested that municipal authorities be aware of all new developments in noise abatement techniques and incorporate these into the bylaws.

Planning of the noise environment should consider market forces, available government controls, public

expectations and technical information. The zoning bylaw is the medium by which all these aspects of planning may be combined. The Composite Noise Rating describes the aircraft noise environment by the use of modern sound measuring expertise and considers the findings relative to the individual. Chapter Six examined the classification of Composite Noise Ratings into Noise Sensitivity Zones on the basis of residential response to aircraft noise. It is suggested that planning decisions consider the Noise Sensitivity Zone classification when establishing compatible land use development and incorporate the classification into the zoning bylaw.

One of the most subtle and pervasive infections of contemporary urban dwellers is noise. Much of today's city noise is a by-product of mechanization and so far our state of progress can be measured with a sound meter. To accept noise as a necessary by-product of our industrial affluence is to be blind to all that true progress implies. All too often those responsible for planning a city conducive to human enjoyment ignore the noise factor as a major planning criterion.

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APPENDIX I

GLOSSARY

ARTERIAL STREET - According to the Street Classification Guide, 1970 (City of Edmonton, Traffic Engineering Department) an arterial street is primarily used for traffic movement and secondarily for access. Arterial streets represent 12 to 20 per cent of total street mileage. Other features of an arterial street include 5,000 to 30,000 vehicles per day, trip lengths of greater than one mile and uninterrupted flow except at signals and crosswalks.

COLLECTOR STREET - According to the Street Classification Guide, 1970 (City of Edmonton, Traffic Engineering Department) a collector street has equal movement and access functions and carries from 1,000 to 12,000 vehicles per day. Collector streets represent 8 to 15 per cent of the total street mileage. Collector streets have trip lengths of less than one mile, are non-continuous for any great length, and contain the transit bus lines.

COMPOSITE NOISE RATING - Developed by the acoustic consulting firm of Bolt, Beranek and Newman, Inc. for the United States Federal Aviation Administration, the CNR is a single number evaluation of an aircraft, its peak noise level, frequency of occurrence and time of occurrence. The CNR's output is a series of contours which are classified according to the degree of subjective response. The classifications serve

as guides to effective planning of land uses exposed to noise.

DECIBEL - A decibel is the logarithm of a non-dimensional ratio of two powers or two power-like quantities, usually sound pressure and may be explicitly stated as;

$$dB = 20 \log_{10} \frac{X_1}{X_2}$$

The multiplier 20 is used because X_1 is a power-like quantity (pressure) and X_2 is the reference sound pressure .0002 microbars which is the threshold of human hearing acuity. The decibel is not a unit of measurement, like a mile or volt. Rather, the decibel is a relative scale of sound pressures.

FREQUENCY - The number of pressure vibrations or complete cycles, which occur per second, determines the frequency of sound and is expressed in cycles per second or Hertz (Hz). One complete vibration of the object corresponds to one complete cycle of pressure change.

HEAD-WIND COMPONENT - A wind blowing directly across the course of an aircraft and therefore, a major factor in determining which direction the aircraft will land or take-off.

LINEAR SCALE - A sound measuring instrument, when operated on the linear scale, will respond equally to all frequencies

in the audio frequency range.

LOCAL ROAD - According to the Street Classification Guide, 1970 (City of Edmonton, Traffic Engineering Department) a local street is primarily used for access to land and secondarily for movement. No transit vehicles move along local streets which represent 65 to 80 per cent of total city street mileage. Trip lengths are less than 0.5 miles.

MACH WAVE RADIATION - When the velocity of the eddy convection in the mixing region of a jet exceeds the ambient speed of sound outside of the jet, Mach wave radiation occurs. Shock waves are generated in the same way as a solid body moving through air at supersonic speeds.

NOISE AND NUMBER INDEX - The Noise and Number Index is based on a questionnaire conducted in London, England during the early 1960s. The index attempts to relate aircraft noise to the degree of annoyance and is given by the formula;

$$\text{NNI} = (\text{average peak noise level}) + 15 \log_{10} N - 80$$

N is the number of occurrences of a sound having a peak level of 80 PNdB or more and 80 is included so that zero NNI produces zero annoyance.

NOISE CLIMATE - The noise climate is the range of sound levels recorded for 80 per cent of the time (the sound levels between the 10 and 90 per cent levels). The 90 per

cent level is an indication of the ambient level which is mainly due to distant traffic activity and the 10 per cent level is the result of intermittent sounds of higher intensity, whether local noises, or the more distant sounds of trains or aircraft.

NOISE FOOT PRINT - The noise foot print is a contour joining points of equal PNdB noise level. The noise foot print is conical in shape because of the operational characteristics of an aircraft.

NOISE INDUCED PERMANENT THRESHOLD SHIFT (NIPTS) - The permanent diminution, following exposure to noise, of the ability to detect weak auditory signals is termed NIPTS. The frequencies showing first and most severe threshold shift are those in the vicinity of 4000 Hz. Steady noises above 80 dBA may produce a change in auditory threshold and above 105 dBA NIPTS will definitely result in a normal unprotected ear if exposure continues, eight hours a day, for several years. NIPTS cannot be reduced except by reducing the noise exposure and there is no way to restore it.

NOY - A scale has been developed that expresses the measure of the perceived noisiness (PN) of occurrences of sounds of equal duration. The unit of the perceived noisiness is called the noy. A sound that is judged to be subjectively equal in noisiness to an octave band of random noise centered at 1000 Hz and a sound pressure level of 40 dB, is given

a value of one (1) noy. A sound judged to be three times as noisy is 3 noy. The noy scale is converted to a logarithmic scale. This scale is called the judged perceived noise level (PNL) scale and its unit is the decibel (PNdB).

PERCEIVED NOISE LEVEL (PNdB) - Researchers have found that the subjectively judged unwantedness of sound or the perceived noisiness is determined by the intensity, bandwidth, spectral content, and duration of the sound. The mathematical formula is;

$$PNdB = 40 + 10 \log_2 PN$$

where $PN = n_{max} + 0.3 \left[\sum_i n_{band\ i} - n_{max} \right]$;

n is number of noys and n_{max} is band containing largest number of noy.

Q FACTOR - The Q Factor (aquivalenter Dauerstorpegel) weights sound levels in dBA according to frequency of occurrence and has been suggested as the basis for an annoyance criteria for traffic noise. The formula is;

$$Q = K \log \frac{1}{100} \sum 10^{Q_i/K} f_i$$

where K is constant, Q_i is the median sound level for the 5 dBA interval i, and f_i is the percentage of sound levels falling within interval i.

<u>SOUND PRESSURE</u> - Sound pressure is the resultant force of the oscillation of particles in an elastic medium and is measured in dynes per square centimetre.

<u>SOUND PRESSURE LEVEL</u> - Sound pressure level, in decibels, is 20 times the logarithm to the base 10 of the ratio of the pressure of the sound to the reference pressure .0002 microbars.

<u>SOUND WAVE</u> - A sound wave is an oscillation of pressure, stress, or particle displacement in an elastic medium which may be a gaseous, liquid, or solid body. Any vibration may be a source of sound but only longitudinal vibration of the conducting medium constitutes sound waves.

<u>SPEECH INTERFERENCE LEVEL</u> - Developed in 1947, the SIL is a measure of noise which, when referred to a table (see Figure 2.2) indicates what voice level is needed to communicate at given distances between talker and listener.

<u>TEMPORARY THRESHOLD SHIFT</u> (TTS) - The temporary diminution, following exposure to noise, of the ability to detect weak auditory signals is termed TTS. Moderate TTS recovers exponentially in time, recovering completely within 16 hours. Recovery of TTS greater than 40 dB, however, is linear in time and may require weeks to disappear. TTS increases linearly with the average noise level, beginning at about 80 dB and extending to about 130 dB. That is, the difference

between TTSs produced by 100 and 110 dB noises is about the same as the difference between those produced by 110 and 120 dB.

<u>TRAFFIC NOISE INDEX</u> (TNI) - The Traffic Noise Index may be expressed as:

4(mean 10% measured sound level − mean 90% measured sound level) + mean 90% measured sound level − 30

The multiplier 4 is to ensure that values of the parameter will be free of fractions and 30 is subtracted to yield convenient numbers, following the example of the Noise and Number Index.

APPENDIX II

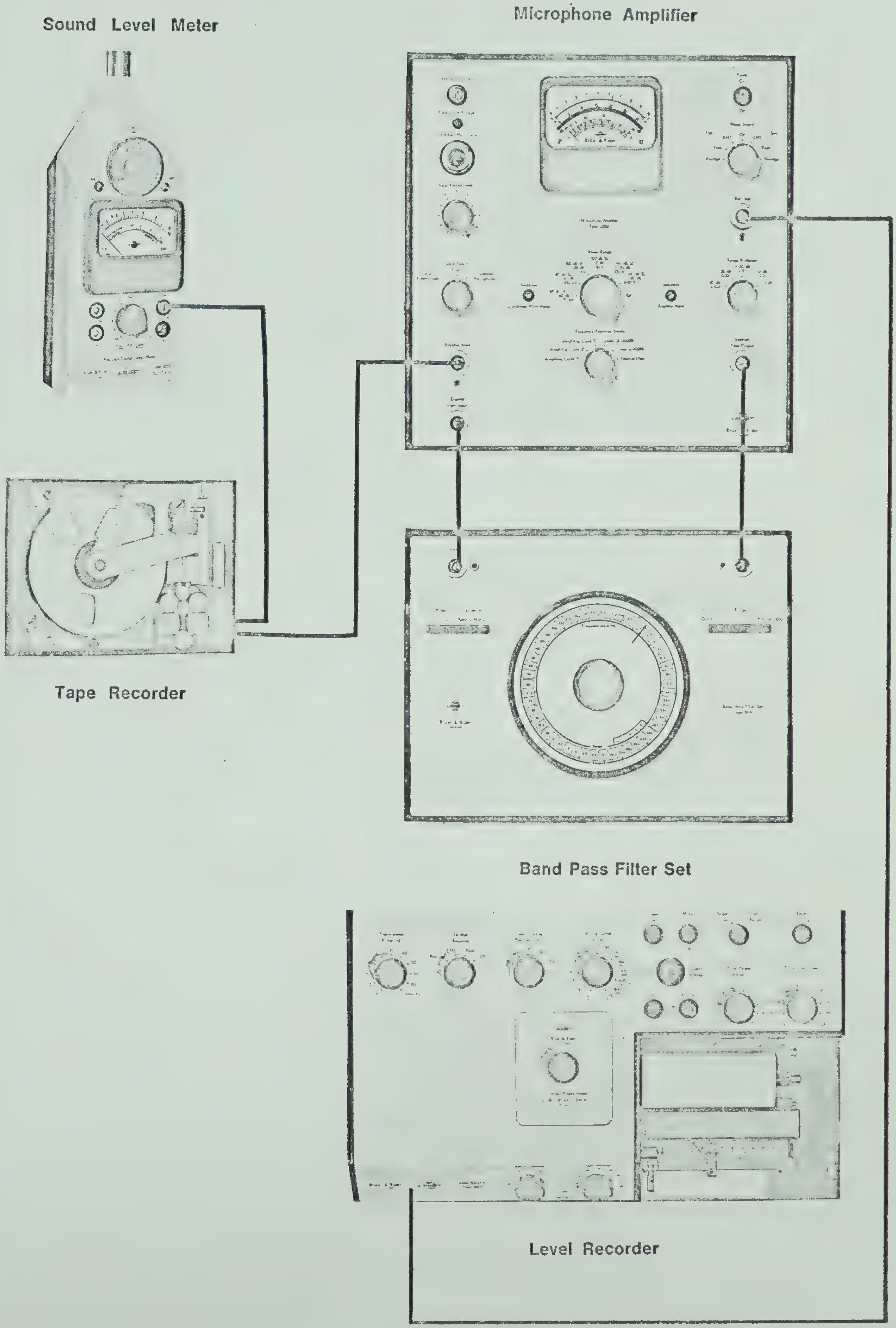
DESCRIPTION OF SOUND MEASURING EQUIPMENT

For the purpose of measuring ambient noise levels within Edmonton a Bruel and Kjaer Precision Sound Level Meter (Type 2203) was used. This instrument is compact and battery operated and has a measuring range of 19 to 150 dB and a frequency range of 10 Hz to 25 kHz. The sound level meter was placed on a tripod, in a horizontal position, approximately 3 feet above ground level. A Random Incidence Corrector (UA 0055) was placed over the microphone to reduce measurement errors involving high frequency aircraft noise. As well, a wind screen consisting of a specially designed foam ball (4 inches in diameter) was fitted over the Corrector to reduce the error introduced by wind. Connected to the sound level meter was a Uher 4000 tape recorder which was chosen because it is able to record high frequencies without distortion and because it is a battery operated instrument. The tape recorder was placed on the ground and recordings were made at least 10 feet from the equipment. Therefore, no error due to reflection from either operator or equipment was introduced. Measurements were made on the linear scale. That is, the ambient noise levels were recorded without any weighting being applied. The time and place of each recording as well as the identification of individual noise sources were spoken into the tape recorder

at the end of each measurement by the operator.

Figure II.i shows the arrangement of instruments used to transfer the noise levels recorded in the field to a graphic ink recording, examples of which appear in the text. The Uher 4000 tape recorder was connected to the Microphone Amplifier (Type 2603) which is a high gain measuring amplifier. A pre-recorded sound level from a Pistonphone (Type 4220) enabled the calibration of the microphone amplifier. A Band Pass Filter Set (Type 1614) was connected to the microphone amplifier to allow the recorded sound to be analyzed according to a particular frequency band. Both the band pass filter set and the microphone amplifier may be used to analyze the sound on an A, B, or C weighting network. The microphone amplifier was connected to the Level Recorder (Type 2305) which is designed to accurately record signals in the frequency range from 2 Hz to 200 kHz. Recordings were made by an ink pen on wax-coated paper (either 100 mm or 50 mm in width). The writing speed and paper speed were adjustable to ensure correct chart recording. The operator listened to each recording and was therefore able to identify the time and particular location of each recording as well as mark on the recording paper the nature of the noise source. The recording paper was divided into 2 dB intervals. A graphic representation of the maximum and minimum levels was therefore obtained. In addition, it was possible to determine the length of time the noise

Figure II.i. Tape- and Graphic Recorder Combinations



levels exceeded any particular level between the maximum and minimum levels.

APPENDIX III

THE BOEING 737-200

Information on the Boeing 737-200 from _Jane's All the World's Aircraft_, ed. J.W.R. Taylor, Scarborough, Ontario, McGraw-Hill Book, Co., 1968, pp. 220-221.

Design work began May 11, 1964 and the first Boeing 737 prototype flew on April 9, 1967.

Type: Twin-jet short-range transport.

Power Plant: Two Pratt and Whitney JT8D-9 turbofan engines in underwing pods. Fuel in two tanks, in outer wings, with total capacity of 2,850 U.S. gallons and a centre wing tank of 1,820 U.S. gallons.

Accomodation: 88 - 113 passengers and baggage. Passenger doors are on port side. Service doors are on starboard side. Overwing escape hatches on each side. Basic passenger cabin has two lavatories aft and a galley forward, opposite passenger door. Freight holds are forward and aft of wing, under floor.

Dimensions:	Wing Span	93 ft., 0 in.
	Length	100 ft., 0 in.
	Height	37 ft., 0 in.
	Tailplane Span	36 ft., 0 in.
	Wheel Base	37 ft., 0 in.

Weights:	Operating Weight	56,069 lb.
	Maximum Payload	31,931 lb.
	Maximum Take-off Weight	107,000 lb.
	Maximum Ramp Weight	108,000 lb.
	Maximum Zero-fuel Weight	88,000 lb.
	Maximum Landing Weight	97,000 lb.

Performance: (estimated at maximum take-off weight)

Performance: (cont'd)

Maximum level speed at 23,500 feet
- 600 m.p.h.

Maximum permissible diving speed
- Mach 0.90

Maximum cruising speed at 20,600 feet
- 573 m.p.h.

Economic cruising speed at 30,000 feet
- Mach 0.78

Stalling speed, flaps down, at maximum landing
- 114 m.p.h.

Rate of climb at sea-level
- 3,200 ft/min

Range with maximum fuel, including reserve for 200 mile flight to alternate airport and 45 minutes continued cruise
- 2,400 miles

Figure III.i. The Boeing 737-200

Boeing 737-200 at Edmonton Industrial Airport

Boeing 737-200 in preparation for flight. Elevated vehicle carries prepared meals for passengers and white cart by the nose of the aircraft is an auxiliary power unit and air conditioner.

APPENDIX IV

EDMONTON COMMUNITY SURVEY

Department of Geography,
University of Alberta,
Edmonton 7, Alberta.

PART I:

1. Address ________________________________

2. Age ______________ 3. Occupation ________________

4. Education _________________ 5. Marital Status ______

PART II:

1. How long have you lived at your present address? _____

2. Where did you live before this? ____________________

3. Why did you move? ________________________________

4. Do you have to travel far to work? No _____ Yes _____

5. Are you far from shopping facilities? No ____ Yes ___

6. In your opinion, what are the most pressing problems in Edmonton today? ________________________

7. Do you feel that the city has dealt sufficiently with problems that have arisen in your neighbourhood?
   No _____ Yes _____
   Please Explain ________________________________

8. What are the main problems in your neighbourhood, if any?
   ____

9. Has the noise level in your neighbourhood increased __ decreased _____ or remained the same _____ since you have moved here?

10. Do you feel that there is too much or too little fuss made about community noise in the news media nowadays?
    ____

11. Does noise ever wake you up_____ wake your children up _____ interrupt conversation _____ interrupt a radio or T.V. programme _____ make your house vibrate _____?

12. What particular noises disturb you? _______________

13. Why, or in what way, are these noises disturbing? _____
____

14. During which time of the day does noise most disturb you? ____

15. Does noise most disturb you when you are working or relaxing? _______________________________________

16. Could you sum up your opinion by saying you find noise in general: very disturbing _____
a little disturbing _____
not at all disturbing _____

17. Have you ever moved your residence because of noise specifically? No _____ Yes _____
If Yes, please explain why _______________________

18. Do aircraft ever make your T.V. flicker _______ make your house vibrate _____?

19. How many aircraft fly over your house each day? ______

20. How long does an aircraft flyover last? ______________

21. Do you have double-glazed or storm windows on your residence? No _____ Yes _____
Are they _____ permanently installed or _____removed during the summer?

22. Which of the following is noisiest?
a propeller-type aircraft taking-off _____
a propeller-type aircraft landing _____
a jet taking-off _____
a jet landing _____

23. To what extent is the Industrial Airport important to the citizen of Edmonton? ___________________________

24. Who owns and operates the Industrial Airport? ________

25. Is noise a necessary by-product of our standard of living? No _____ Yes _____

26. Have you ever complained to the authorities or anyone else (for example, a neighbour) about neighbourhood problems? No _____ Yes _____

27. In particular, have you ever complained about noise? No_____ Yes _____

28. What government agency is involved in noise control?
____

29. Do you feel that industry is aware of the noise problem?
No _____ Yes _____ Are they doing anything about it?
No _____ Yes _____ If YES, please explain _________

30. Do you feel that complaints by the private citizen 'do any good'? _______________________________

APPENDIX V

BYLAW NO. 23, 1925

A Bylaw to prevent certain noises likely to disturb the inhabitants.

The Municipal Council of the City of Edmonton duly assembled enacts as follows:

1. No person shall blow or sound or cause to be blown or sounded within the limits of the City of Edmonton, the steam whistle of any locomotive for the purpose of making up trains or for purposes other than those authorized or required by the Statutes of the Dominion Parliament or the Legislature of the Province of Alberta relating to railways and by regulations made under such Statutes.

2. No person shall within the limits of the City of Edmonton make or cause to be made any unusual or unnecessary noise or noise likely to disturb persons in his neighbourhood.

3. No person shall permit or allow any unusual or unnecessary noise or noise likely to disturb persons in the neighbourhood to be made upon any premises occupied by him or under his control within the City of Edmonton.

DONE AND PASSED in Council this 23rd day of November, 1925.

Sgd. "K.A. Blatchford"
MAYOR

Sgd. "Chas. Ed.K. Cox"
CITY CLERK

APPENDIX VI

BYLAW NO. 3256

A Bylaw to prohibit, eliminate or abate noise within the City of Edmonton

WHEREAS Section 157 (1)(g) of The Municipal Government Act provides the Council may pass a bylaw "for the purpose of prohibiting, eliminating or abating noise"; and

WHEREAS the said Section 157 also provides that the Council may by bylaw prevent or compel the abatement of nuisances generally; and

WHEREAS the intent of this bylaw is to prevent a deterioration of the noise environment in this City and to adopt as the acceptable noise level a reading in dBA units according to a sound level meter used as herein provided:

NOW THEREFORE the Municipal Council enacts as follows:

1. This bylaw may be cited as "The Noise Abatement Bylaw".

2. In this bylaw,
   (a) "City" means The Corporation of The City of Edmonton or the area contained from time to time within the boundaries of the City as the context requires.

   (b) "commercial and industrial area" means such areas as these are defined in the Zoning Bylaw and the Development Control Bylaw of the City.

   (c) "noise level in dBA units" means the reading of any sound level meter which meets the International Electro-technical Commission Standard No. 123 or the British Standard No. 3539 part 1, or the USA Standard S1.4-1961, when such meter is set on the A-weighting

network and the fast response.

(d) "night" shall mean the period between 9:00 o'clock in the afternoon and 6:00 o'clock in the forenoon of the following day.

(e) "residential zone" means what is classed as residential by the Edmonton Zoning Bylaw and the Development Control Bylaw of the City.

(f) "signalling device" means a horn, gong, bell, klaxon or other device producing an audible sound for the purpose of drawing people's attention to an approaching vehicle, including a bicycle.

(g) "vehicle" means a vehicle as defined in Section 2 of the Highway Traffic Act, Ch. 30, Statutes of Alberta, 1967, as amended.

(h) "Zoning Bylaw" means Bylaw No. 2135, as amended from time to time, and includes any bylaw passed in substitution for or in addition to Bylaw No. 2135.

GENERAL ABATEMENT PROVISION

3. (1) No person shall make or continue any loud, unnecessary or unusual noise which disturbs the comfort and repose of other persons within the limits of the City, except to the extent permitted by this bylaw.

(2) Except as otherwise herein provided, no person shall allow property belonging to him or under his control to be used so that there originates from the property any loud, unnecessary or unusual noise which disturbs the comfort or the repose of other persons in the vicinity of such property or generally within the limits of the City.

(3) What is a noise of a level to interfere with the comfort or the repose of any person or persons so as to justify a prosecution under this bylaw is a question of fact for the Court that hears the charge, provided that when the Court is satisfied that the noise by its nature and in the circumstances should be abated the fact that it is within the dBA rating permitted herein shall not be deemed to prevent a finding under this section that abatement is required.

4. No person shall operate or cause to be operated a passenger vehicle or truck that has a gross weight of less

than 6,000 pounds, the noise from which vehicle measured at a distance of not less than 15 feet from the traffic lane in which the vehicle is standing or moving has a level greater than 83 dBA, except for the operation of a "signalling device".

5. No person shall operate or cause to be operated a motor-cycle, the noise from which motor-cycle measured at a distance of not less than 15 feet from the traffic lane in which the motor-cycle is moving or standing has a level greater than 88 dBA in the daytime and 83 dBA at night, except for the operation of a "signalling device".

6. (1) No person shall operate or cause to be operated a passenger vehicle or truck with rated gross vehicle weight of 6,000 pounds or more, the noise from which truck or passenger vehicle measured at a distance of not less than 15 feet from the traffic lane in which such vehicle is standing or moving has a level greater than 90 dBA, except for the operation of a "signalling device".

(2) When heavy equipment is being used by the City to build roads or to grade or to sweep and clean roads or to remove snow therefrom, then a noise level not exceeding 90 dBA will be permissible, providing the noise is only of such duration as is reasonably necessary to improve the highway condition.

7. A noise level in a residential or in a commercial and industrial area shall be measured at the property line of the property from which the noise is emanating.

8. No person shall cause nor permit to be caused a noise level in a residential zone during daytime hours that exceeds 65 dBA unless the noise level results from an emergency situation or unless the noise level has been approved by a special permit issued by the City Commissioners or unless the noise is a temporary and intermittent noise.

9. No person shall cause or permit to be caused in a residential zone during daylight hours a temporary or intermittent noise except to the extent herein set forth:

Time	2 Hours	1 Hour	30 Minutes	15 Minutes
dBA	70	75	80	83

The time indicated in the table is the total elapsed time in any calendar day.

10. No person shall cause nor permit to be caused in a residential zone during the night hours any noise that registers more than 50 dBA, except as otherwise provided

under traffic noise control and regulations of the Edmonton Traffic Bylaw and the Edmonton Streets Bylaw.

11. No person shall cause nor permit to be caused in a commercial and industrial zone a noise level limit in excess of 75 dBA except for intermittent noises or those created in an emergency situation or such noises as are permitted temporarily by a special permit issued by the City.

12. In a commercial and industrial zone a person may cause or permit an intermittent noise in accordance with the following table:

Time	2 Hours	1 Hour or less
dBA	80	85

The time indicated in the table is the total elapsed time in any calendar day.

13. Where a special permit is issued by the City Commissioners, either in a residential zone or in a commercial and industrial zone, the special permit shall be limited to a minimum period deemed practicable by the Commissioners and the decision of the Commissioners may be appealed to a Court of Law.

ADMINISTRATION

14. Every person authorized by the City to measure noise levels in accordance with the foregoing standards shall use a sound level meter which meets the International Electrotechnical Commission Standard No. 123 or the British Standard No. 3539 part 1, or the USA Standard S1.4-1961, when such meter is set on the A-weighting network and the fast response. The instrument shall be complete with calibrator and wind screen.

15. The use of such a sound level meter shall be in compliance with the instructions that are included as Appendix A to this bylaw so that due regard will be had when measuring noise levels to unusual weather conditions, unusual noise surroundings or the like.

16. Every person who contravenes or permits contravention of the provisions of this bylaw shall upon conviction thereof forfeit and pay at the discretion of the convicting magistrate a fine of not more than $500.00 for each offence.

Bylaw No. 23 of 1925, being a bylaw to prevent certain noises likely to disturb the inhabitants, is hereby repealed.

APPENDIX VII

EXPLANATORY NOTES ON COMPATIBLE LAND USE TABLES

It is important to understand that the locations of the lines between noise zones cannot be fixed exactly. It will be necessary in some specific cases, therefore, for the responsible public authority to make an appropriate interpretation of what regulations are to be made applicable.

A. A marginal zone exists near the 100 CNR and noise may start to become a problem. It is recommended that developers be made aware of this fact and that they be required to so inform prospective tenants or purchasers of residential units. In addition, it is suggested that development should not proceed until an analysis of the noise environment is made and it is established what noise control features are to be included in the building design.

B. The developer should be made aware of the noise problem and he should undertake to relay this information to all prospective tenants or purchasers of residential units. Moreover, construction should not occur unless a detailed analysis of noise reduction requirements for the specific development in question is made and needed noise control features are included in the building design.

C. Generally these uses should not locate in this zone. Detached and semi-detached dwellings could be permitted as 'infilling' in those areas where sub-divisions are in being or have received draft approval. If development is to occur it should be subject to the requirements of Note B.

D. Generally no apartments should be constructed in this zone. Where it can be demonstrated that the proposed development constitutes a limited amount of infilling, however, development could be permitted but subject to the requirements of Note B.

E. It is advisable that these kinds of uses not be located close to the 100 CNR line but if they are it is <u>strongly</u> recommended that they be subject to the conditions of Note F.

F. This use should not be approved unless a detailed analysis of noise reduction requirements for the specific development in question is made and needed noise control features are included in the building design.

G. Generally none of these uses should be constructed in this zone. Where it can be demonstrated, however, that these uses are the most appropriate ones in specific cases, taking into account all relevant factors, construction may occur provided a detailed analysis of noise reduction requirements for the specific development in question is made and needed noise control features are included in the building design.

K. While research has shown that animals may condition to high noise levels, it is recommended that serious consideration be given to the peak noise levels before this use is allowed. (Further research may, in fact, find that the hearing ability of stock animals is impaired by high noise levels. If so, then an unhealthy environment would exist.)

L. Many of these uses would be acceptable in all CNR zones. An analysis should be conducted, however, to determine internally generated noise levels in the working area and the degree of sound proofing required.

M. When associated with a permitted land use an office would be considered taking into account all relevant factors including a detailed analysis of the noise reduction requirements to provide the environment necessary for the specific office function.

N. Undesirable if there is spectator involvement.

P. It is recommended that serious consideration be given to peak noise level and its effect on the specific use under consideration.

Source: Ontario Department of Municipal Affairs, 1969.

APPENDIX VIII

TABLE VIII.i. RANKING OF MOVEMENTS AT MAJOR CANADIAN AIRPORTS FOR 1969
(Edmonton Industrial Airport Annual Report, 1969)

	Total		Itinerant		Local	
Rank	Name	No.	Name	No.	Name	No.
1	St. Hubert	289,718	Toronto Int	165,426	St. Hubert	211,460
2	Montreal Int	257,708	Montreal Int	148,027	Buttonville	148,149
3	Calgary	218,737	Vancouver Int	142,120	Toronto Isl	147,649
4	Buttonville	212,031	Winnipeg Int	114,161	Calgary	140,814
5	Toronto Int	210,708	Ottawa Int	93,194	Edmonton Ind	113,729
6	Toronto Isl	209,181	Edmonton Ind	86,388	Ottawa Int	96,083
7	Edmonton Ind	202,027	St. Hubert	74,436	Montreal Int	93,821
8	Ottawa Int	199,898	Calgary	70,060	Pitt Meadows	89,945
9	Winnipeg Int	179,932	Toronto Isl	61,532	Hamilton City	88,875
10	Vancouver Int	169,602	Pitt Meadows	52,995	St. Andrews	84,299
11	Pitt Meadows	142,940	Quebec	52,032	Cartierville	83,344
12	Cartierville	126,859	Victoria Int	51,787	London	70,722
13	Quebec	123,373	Cartierville	43,515	Quebec	69,639
14	Hamilton City	117,918	London	42,820	Moncton	63,229
15	London	115,841	Abbotsford	40,339	Regina	60,847

TABLE VIII.ii. EDMONTON INDUSTRIAL AIRPORT MOVEMENTS

(Edmonton Industrial Airport
Annual Report, 1969)

Year	Total	Itinerant	Local
1953	195,938	32,114	163,824
1954	155,124	36,367	118,757
1955	183,450	46,254	137,196
1956	196,196	50,910	145,286
1957	208,421	53,930	154,491
1958	219,662	57,226	162,436
1959	225,193	59,139	166,054
1960	(3) 225,696	(6) 57,796	(2) 161,698
1961	(5) 162,622	(7) 45,650	(4) 112,006
1962	(6) 146,292	(7) 46,810	(3) 95,480
1963	(8) 141,196	(7) 49,489	(4) 88,055
1964	(6) 142,191	(8) 49,483	(3) 90,492
1965	(6) 166,831	(8) 59,464	(4) 104,580
1966	(6) 190,272	(7) 68,942	(5) 119,031
1967	(8) 184,250	(7) 75,521	(8) 106,459
1968	(6) 202,178	(7) 82,652	(6) 117,105
1969	(7) 202,027	(6) 86,388	(5) 113,729

(7) ranking of airport among tower equipped Canadian airports.